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STUDIES ON THE MUSCULATORY SYSTEM AND MOUTH PARTS OF LAELAPS ECHIDNINUS BERL.*

JOHN STANLEY,
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Some time ago, while working with rats containing the rat trypanosome, *T. lewisi*, the writer became interested in the small ectoparasitic mite *Laelaps echidninus* Berl. which is commonly associated with them. Since the literature on the internal anatomy of Gamasids is not voluminous, and is in general somewhat vague as to exact details, a careful study of mouth-parts and the musculatory system seemed desirable and yielded results which it seems desirable to place on record as a starting point for future work.

Of previous studies the most important is that of Michael, in 1892. Other important papers bearing on the problem are cited in the bibliography.

This work was undertaken by the writer while an assistant in the Department of Zoology and later of Entomology at the University of Minnesota. To Dr. W. A. Riley and Dr. R. N. Chapman he wishes to acknowledge indebtedness for facilities and for encouragement in carrying it out.

CAPITULUM, MOUTH-PARTS AND PHARYNX.

The Acarina in general show but little demarcation of head, thorax and abdomen, and in *Laelaps* no external trace of exact demarcation exists between the thorax and abdomen.

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The head, or more properly the capitulum is, however, quite distinct, but differs markedly from the Hexapod head, being in the form of a more or less elongate cylindrical capsule attached to the ventrocephalic surface of the thoracic region by a belt of non-chitinised tissue. It bears the mouth parts at its distal end, and by the action of certain muscles to be described later, it may be partially retracted within the body.

Its interior cavity is occupied dorsally by the large and strong sheaths of the retractible mandibles, Fig. 3 and Text Fig. 1 (ms). and ventrally by the complicated musculature of the sucking pharynx. (For ease of orientation, we shall assume the head to be held in a strictly prognathous position.)

The mouth parts, themselves, form a group of more or less lanciolate structures, with its long axis approximately collinear with that of the capitulum capsule itself.

Anteriorly, the mandible sheaths are fused in the middle line; posteriorly they are entirely separate from each other.

At their anterior ends, also, they become fused with the dorsal wall of the capitulum capsule, Figs. 3 and 5 (f), and Text Fig. 1, and in the same region, also, a stout bar of chitin extends from the ventral surface of each sheath to fuse with the ventral surface of the capitulum capsule, Figs. 3 and 5 (b), and Text Fig. 1.

Thus, from Text Fig. 1, particularly, it will be evident that at its anterior end, the tube forming the shell of the capitulum becomes divided into five "pigeon holes;" dorsally, the two mandible sheaths, laterally the two openings (stp), the stipes of the palpi, into which the scapes of the palpi are set, and ventrally the opening (m) through which the sucking pharynx opens. The rim of (m), together with the walls of the anterior part of the pharynx, forms the support for the lingula, maxilla, etc.

Dorsally, the capsule of the capitulum is prolonged anteriorly to form a long, flap-like epistome, Figs. 1 and 2 (ep) which partially surrounds and encloses the mouth-parts proper. There is no evidence that the epistome is fused laterally with any of the mouth-parts as Banks mentions may be the case with some Acarina.

The mandibles, themselves, are three-jointed, chelate, and may be protruded from or withdrawn into the mandible sheaths, from whose anterior openings they project. This retraction is effected by the powerful muscles, Fig. 5 (mm), which have their origin on the dorsal wall of the thoracic region, and their insertion within the basal joint of the mandibles.

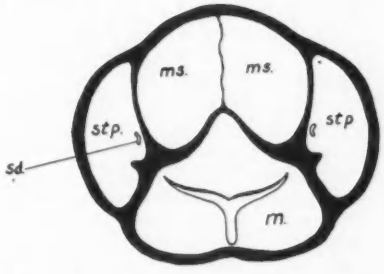
Between the bases of the mandibles, ventral to them, and having their support partially on the thickened anterior ends of the mandible sheaths, and partially on the anterior end of the dorsal wall of the pharynx, are the lanceolate vomer (v) and the lingula (l), Figs. 1, 2 and 3.

The vomer is, in this species, quite large and is grooved along the ventral surface. In the normal position, the dorsal ridge of the lingula lies in this groove. The lingula is also grooved on the ventral surface, Figs. 1, 2 and 3 (ge), the groove extending into the opening of the

pharynx, and in all probability, aiding in the flow of blood from the wound to the pharynx. The ventral surface of the lingula is continuous with the dorsal wall of the pharynx.

Throughout its length, the pharynx is in the form of a triangular tube, the walls of which may be buckled inward by the action of certain constrictor muscles, so that in section, it assumes the form of a three-pointed star. At the extreme anterior end, however, such constrictor muscles are absent, the tube remaining in the triangular form.

The dorsal wall, as we have said, merges with the ventral surface of the lingula, but the ventro-lateral walls spread outwards to approach the walls of the capitulum capsule, and fusing with them, form the support for the maxillæ, Figs. 1, 2 and 3 (max) and the two divisions of the hypostome (hy).



TEXT FIG. 1. Diagrammatic cross-section of distal end of capitulum capsule, at the base of the mouth parts.
Ms, Mandible sheath. Stp, Stipes of palpus. M, Cavity of ligula, maxillæ, etc. Sd, salivary duct.

These two hypostomal prolongations, together with the maxillæ, partially enclose the vomer and lingula on the ventral and lateral aspects, the enclosure being completed by the thin chitinous styli, Figs. 1, 2 and 3 (st). The styli have their support on the median surface of the stipites of the palpi.

The latero-dorsal edge of each maxilla is slightly grooved and the ventro-median edge of the stylus, fitting into this groove, loosely locks the two structures together.

The salivary duct, Text Fig. 1 (sd), enters the interior cavity of each palpal stipes, but almost immediately crosses through the substance of the median wall, to enter the stylus, which it follows to the tip, opening to the outside through a small pore.

The palpus itself is five-jointed, Figs. 1, 2 and 3 (pal).

MUSCULATURE OF THE PHARYNX.

The peristaltic movement of the pharynx is brought about by the action of three sets of constrictor muscles, Figs. 2 and 3 (vl), (d) and four sets of extensors (vle), (de), (le).

The three sets of constrictors are alike in form, each muscle being attached at the ends to the pharynx as shown, and on contraction they cause the sides of the triangular tube to buckle inward along the middle line.

The two ventral sets (vl), are arranged directly opposite to each other, and number seven muscles each, while the dorsal sets (d) contain six muscles which are not arranged exactly opposite to those of the ventro-lateral sets.

The most anterior muscle of (d) coincides in position along the tube with the corresponding muscles of (vl), but more posteriorly, the positions of the muscles of (d) are progressively more and more posterior to those of (vl), so that the sixth muscle of (d) is midway between numbers six and seven of (vl). This asymmetry would seem to be inevitable when the placing of the extensors is considered, but it may incidentally result in a more even peristalsis.

The extensors are larger and more powerful than the constrictors. Two ventro-lateral sets, Figs. 2 and 3 (vle), have their origin on the ventro-lateral walls of the capitulum and their insertion on the ventro-lateral walls of the pharynx, thus working in opposition to the constrictors (vl).

In general, the positions of the individual muscles of (vle), alternate with those of (vl), but the whole assembly is placed more anteriorly, the eighth and most posterior muscle of (vle) being between numbers six and seven of (vl).

The individual muscles differ in complexity, numbers one and two being single, but from the third, counting toward the posterior end, each is double. (See Fig. 2). In some specimens the division was a little doubtful in the case of number three, but it seemed more often present than absent. There was some indication, too, that numbers seven and eight might be triple.

The two dorso-lateral sets of extensors, Fig. 3 (de) numbering five muscles each, have their insertion on the dorsal wall of the pharyngeal tube, but the individual muscles divide themselves into two groups on the matter of origin. The two anterior of each set have their origin on a thickened ridge on the ventral surface of the mandible sheath, Fig. 3 (rms), while the three posterior muscles originate from a ridge on the lateral wall of the capitulum, Fig. 2 (ltr). This ridge appears in cross-section in Fig. 2, but it curves obliquely in an anterio-dorsal direction, and finally comes to a position on the lateral wall.

The insertions of these extensors (de) are between those of the constrictors (d) and are without regard to the positions of the constrictors (vl). The first and most anterior muscle is inserted midway between numbers one and two of the constrictors (d).

At the point of origin, these three posterior muscles of each set (de) appear to be fused, but they separate about half way between the origin and insertion; they are somewhat larger and more powerful than the two which have their insertion on the mandible sheaths.

Finally, there is a group of muscles, Fig. 3 (le) which has its origin on the ventral surface of the mandible sheaths at the posterior end, and

its insertion on the dorsal wall of the pharynx at its extreme anterior end, opposite the first and second extensors of the sets (vle).

In cross-section, this group divides itself into four sub-groups. The dorsal pair lie closely appressed in the groove between the mandible sheaths, and have their origin on the mandible sheaths at a point about opposite to the fifth ventro-lateral constrictor.

The two more ventral sub-groups have their insertion posterior to that of the dorsal pair and their origin about opposite to the sixth ventro-lateral constrictor.

The purpose of these muscles is not quite so obvious as in the case of the other constrictors and extensors, but it seems reasonable to suppose that they act in opposition to the first and second ventro-lateral extensors, since at that point on the pharyngeal tube, there are no typical dorsal extensors comparable to those situated more posteriorly.

It is interesting to note that the muscles of the sucking pharynx are non-striated.

Musculature of the Thoracic Region.

Before going on to a discussion of the structures involved in the musculature of the thoracic region, it is necessary to give some explanation of Plates II and III.

In the case of Fig. 5, Plate II, that portion of the specimen posterior to the plane of division between the thoracic and abdominal regions has been entirely removed. The thoracic region and the capitulum have been divided by a median longitudinal section. Thus, the figure shows the interior of the left half of the thoracic region.

Figs. 6 to 18 of Plate III were obtained from the model of Fig. 5 by cutting the same into seven rather thick cross-sections, each of which, with the exception of that of Fig. 6, is viewed first from the posterior, and then from the anterior aspect. The posterior aspect of that of Fig. 6 is not repeated on Plate III, since it is shown at the extreme left of Fig. 5.

Thus, numbering the sections from posterior to anterior, Fig. 6 is the anterior face of Section 1. Figs 7 and 8 are the posterior and anterior faces respectively, of Section 2, and so on, until Figs. 17 and 18 are the posterior and anterior faces of Section 7, the most anterior of all the sections.

The muscles (mm) retracting the mandibles, and the muscles (lar) retracting the capitulum have been removed. These have their origin beneath the dorsal surface of Section 5, that is of Figs. 9 and 10, and continue along beneath the dorsal surface of the succeeding sections, as in Fig. 5.

Nomenclature of the Muscles.

No satisfactory method of naming the muscles has been worked out, as the writer feels that any such system should have phylogeny and ontogeny as a basis, two subjects which have not been investigated in this study.

In order to distinguish them for purposes of description, numbers are used. Thus, all muscles labelled 4:1, 4:2, 4:3, etc., are concerned with the movement of the fourth leg. Similarly all muscles labelled 3:1, 3:2, 3:3, 3:4, etc., are concerned with the movement of the third leg, and so on. The few muscles not actuating a leg will be denoted by abbreviations of suitable names.

Types of Muscles.

The muscles of the thoracic region of *L. echidninus* may be classified under 7 types, thus:

Class 1: With origin on the body wall.
- Type (a). With insertion on the inner surface of a coxa.
- Type (b). With insertion on the outer surface of a coxa.
- Type (c). With insertion also on the body wall.
- Type (d). With insertion within the capitulum or its associated structures.

Class 2: With origin on the endoskeletal frustule.
- Type (a). With insertion on the inner surface of a coxa.
- Type (b). With insertion on the outer surface of a coxa.
- Type (c). With insertion on the body wall.

It might be noted, in passing, that the origin of the endoskeletal frustule was for some time a disputed point until Bernard, in 1896, showed that in the case of the *Galeodidæ*, it is formed as a result of the expansion and fusion of lateral apodemes. It seems probable that the analogous structure in *L. echidninus* is homologous with this.

Centres of Origin for Muscles, on the Dorsal Surface of the Thoracic Region.

Those muscles having their origin beneath the dorsal surface of the thoracic region and of the abdomen spring from fifteen well-defined centres, seven on each side and one above the frustule. In a sense, that above the frustule is also paired, but may be treated as a single centre. The paired lateral centres are situated as follows:

- (Ce1). Anterior to the first coxa close to the median line.
- (Ce2). Above the first coxa.
- (Ce3). Above and between the first and second coxae.
- (Ce4). Laterad of the frustule, and above the third coxa.
- (Ce5). Laterad of the frustule, and above the fourth coxa.
- (Ce6). Above the fourth coxa, somewhat laterally placed, posterior to (Ce5).
- (Ce7). On the dorso-lateral surface of the abdomen, about one-half way between the abdomino-thoracic boundary and the anus.

The description of these muscles may be conveniently tabulated as follows, the numbers in the right hand column referring to additional notes which follow the tabulation:

TABULATION OF THORACIC MUSCLES.

No.	FIGURES	TYPE	ORIGIN	ATTACHMENT	REMARKS
4:1	6	1a	Ce7	Inner-posterio-lateral surface, Coxa 4	1
4:2	6	1a	Ce6	Anterior to 4:1	
4:3	7, 8	1b	Ce5	Outer surface, at apex; interior prolongation Coxa 4	
3:1	7, 8	1b	Ce5	Analogous position on Coxa 3	2
3:2	9	2b	On frustule, close to lateral edge	Anterior to 3:1	
3:3	9, 10	2b	Frustule, mesad of 3:4	Outer mesal surface, base of Coxa 3	3
3:4	7, 8	2b	Frustule, posterior to 3:2 and 3:3	Outer posterior face base of Coxa 3	
3:5	9, 10	1a	Ce4	Inner lateral surface Coxa 3	4
3:6	10, 11	2a	Frustule, anterior to 3:2 and 3:3	Inner anterior surface, Coxa 3	
2:1 2:2	10, 11, 12	2b	Frustule, anterior to 3:6	Outer posterior lateral face, Coxa 2	
2:3	11, 12	2b	Similar to 2:2	Laterad of 2:1, 2:2	
2:4	11, 12, 13, 14	2a	Frustule, anterior end	Inner mesal surface, Coxa 2	5
2:5	13, 14	1b	Ce3	Outer mesal side of foramen, Coxa 2	
2:6	13, 14	1a	Ce3 Laterad 2:5	Inner mesal surface, Coxa 2, posterior to 2:4	
2:7	13, 14	1a	Ce3 Laterad, 2:5 and 2:6	Inner lateral surface, Coxa 2	6
2:8	15, 16	2a	Ce3 Anterior to 2:6 and 2:7	Inner anterior surface, Coxa 2	
2:9	11, 12	1b	Lateral body wall	Outer lateral surface, Base Coxa 2	7

TABULATION OF THORACIC MUSCLES—Concluded.

No.	FIGURES	TYPE	ORIGIN	ATTACHMENT	REMARKS
1:1	14, 15, 16	1b	Ce3 Anterior to 2:8	Outer posterior side rim of foramen of Coxa 1	
1:2	15, 16	1a	Ce3 Mesad of 1:1	Inner mesal surface of Coxa 1	
1:3	17, 18	1a	Ce2	Inner, anterio-mesal surface, Coxa 1	
1:4	17, 18	1a	Ce2	Corresponding point to 1:3 on inner anterio-lateral surface	
1:5	17, 18	1a	Ce1	Inner anterior surface, Coxa 1	8

REMARKS ON THORACIC MUSCLES TABULATED ABOVE.

NOTE 1. 4:1 is the only leg muscle having origin at Ce7.

NOTE 2. The muscle 3:1 is analogous to the muscle 4:3 in the case of the fourth leg.

NOTE 3. The muscle 3:3 has its origin on the frustule, immediately mesad of 3:2, and its insertion, apparently, at the base of Coxa 3, on the mesal surface. Winkler (1886) claimed that such a muscle has insertion on the ventral sclerite at the lateral margin. The writer is in doubt about this point. The majority of the sections examined seemed to show the insertion as figured, while some gave an indication of the insertion claimed by Winkler. The writer prefers to leave it a moot point.

NOTE 4. The muscle 3:5 is shown in a relaxed condition in the figures. It occurs uniformly in this condition in the sections.

NOTE 5. The muscle 2:4 has origin at the anterior end of the frustule, and passing in an anterio-ventral direction passes mesad of the muscle 2:5 to its insertion on the inner mesal surface of Coxa 2. The writer can offer no explanation of such a remarkable path. It would seem that on contraction of 2:4, the muscle 2:5 would be pulled laterad. There is, of course, the possibility of an error in the interpretation of the sections, since there is a maze of cut muscle-ends in this region. However, a great deal of time was spent on these sections and the writer feels that such a mistake is unlikely.

NOTE 6. The muscle 2:7 would seem to work in direct opposition to 2:6.

NOTE 7. The muscle 2:9 is rather unusual, having its origin very low down on the lateral wall of the body, and its insertion on the base of

the coxa, on the lateral surface. Such a muscle was not found in the case of any other leg but the second.

NOTE 8. The muscle 1:5 is composed of three heavy and distinct fascia.

MUSCLES OF THE CAPITULUM.

The large mandibular retractor muscles, having their origin at the median centre, above the frustule, have already been mentioned.

The movements of the capitulum itself are controlled by six sets of muscles, three on each side of the body, and may be tabulated as follows:

DES.	FIGURES	ORIGIN	ATTACHMENT	REMARKS
1ar	5, 14, 15, 16	Just anterior to mandibular retractors	Anterio-lateral corners, rim, capitulum capsule	
1mr	5	Ce1, or just anterior to it	Extreme lateral portions	See note
1pr	5, 14, 15, 16	Ce3	Posterio-lateral corners, rim of capitulum capsule	

With regard to the second group (lmr) there is some doubt in the writer's mind as to the actual existence of such a group. In longitudinal sections, the muscles 1:5, Figs. 17 and 18, are very likely to be mistaken for muscles actuating the capitulum, especially as the actual points of insertion are very difficult to determine, even with an oil immersion lens. The same mistake may be made in cross-sections when the capitulum is in a partially retracted condition. Michael (1892) shows such muscles in Fig. 72 of his work on Gamasids, but it is to be noted that the figure does not commit itself to a definite insertion on the rim of the capsule. In fact, it shows exactly the same vagueness as appears in actual sections.

MUSCLES OF THE SPIRACLE.

A small group of fasciculæ, apparently only two, Figs. 5, 7 and 8 (spm) has its origin at the fifth lateral centre (Ce5) and its insertion on the body wall immediately anterior to the spiracle. It is thus of Type lc, and is concerned with the movement of the spiracle. Whether it operates to open or to close it, could not be determined.

SUPPORT OF THE ENDOSKELETAL FRUSTULE.

The endoskeletal frustule, Figs. 5, 7, 8, 9 and 10 (esk) is attached to the dorsal wall of the body by supports of a more or less tendinous nature, Figs. 7, 8, 9, 10 and 11 (lfm), (dfm).

One pair, each of which is double, (dfm) extends upward from the dorsal surface of the frustule to the dorsal wall of the thoracic region. The other (lfm) extends laterally from a similar position to the dorso-lateral wall of the thoracic region.

Summary.

1. It has been shown that the mouth-parts of *Laelaps echidninus* Berl. form a lanceolate and partially interlocked group at the distal end of the capitulum, of which group, the mandibles are retractible through the action of large muscles having origin far back on the dorsal wall of the thoracic region.

2. The pharynx itself was shown to be of the sucking type, having the form of a three-pointed star in cross-section.

3. It was also shown that the peristaltic movement of the pharynx is caused by the action of five sets of extensor muscles, and three sets of constrictor muscles, disposed along the length of the tube. The origin of these muscles varies, being upon the tube itself, upon the wall of the capitulum capsule, or upon a thickened ridge on the ventral surface of the mandible sheaths.

4. It was further shown in the case of the musculature of the legs, that the muscles could be divided up into a number of types on the basis of origin and insertion, and that they differed markedly from any arrangement found in insects, being, so to speak, "festooned" from the dorsal wall of the thoracic region, and from an endoskeletal frustule originating by the fusion of apodemes. Doubt was expressed as to the exact insertion of several of these muscles.

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EXPLANATION OF PLATES.

PLATE I.

(Figs. 1, 2, 3).*

Fig. 1. Capitulum from the ventral aspect.

MA, Mandible.
PAL, Palpus.
L, Lingula.
EP, Epistome.
ST, Stylus.
MAX, Maxilla.
HY, Hypostome.
STP, Stipes of Palpus.

Fig. 2. Capitulum from ventral aspect, with ventral surface removed, mouth parts cross-sectioned.

V, Vomer.
VLE, Ventro-lateral extensor muscles of pharynx.
VL, Ventro-lateral constrictor muscles of pharynx.
LTR, Lateral ridge for attachment of dorsal extensors.

Fig. 3. Capitulum from right side, with right and ventral surfaces removed.

B, Chitinous bar connecting mandible sheath to ventral wall of capitulum capsule.
LE, Longitudinal extensor muscles of pharynx.
MS, Mandible sheath.
F, Fusion of mandible sheath with capitulum capsule.
D, Dorsal constrictors of pharynx.
DE, Dorsal extensors of pharynx.

PLATE II.

Fig. 5. Interior view of left half of thoracic region.

C:1, C:2, C:3, C:4, Coxae.
T:1, T:2, T:3, T:4, Trochanters.
CE. 1, CE. 2, CE. 3, etc., Lateral centres of origin for muscles.
4:1, 4:2, 4:3, etc., Muscles actuating fourth leg.
3:1, 3:2, 3:3, etc., Muscles actuating third leg, and so on, for first and second legs.
MM, Retractor muscles of mandibles.
ESK, Endoskeletal frustule.
LFM, Dorso-lateral support of frustule.
SPM, Muscle actuating spiracle.
SPI, Spiracle.
PVM, AVM, Small muscles connected to ventral sclerite.
LPR, Latero-posterior retractors of capitulum.
LMR, Latero-mesal retractors of capitulum.
LAR, Latero-anterior retractors of capitulum.
C, Capitulum capsule.
F, Fusion of mandible sheaths with capsule.
MS, Mandible sheaths.
B, Chitinous bar connecting mandible sheaths to capsule.

PLATE III.

Figs. 6–18, incl. Posterior and anterior faces of thick sections cut from a model of the left half of the thoracic region, with certain muscles and portions of the capitulum removed.

(Letters used as designations same as for Plate II, Fig. 5.)

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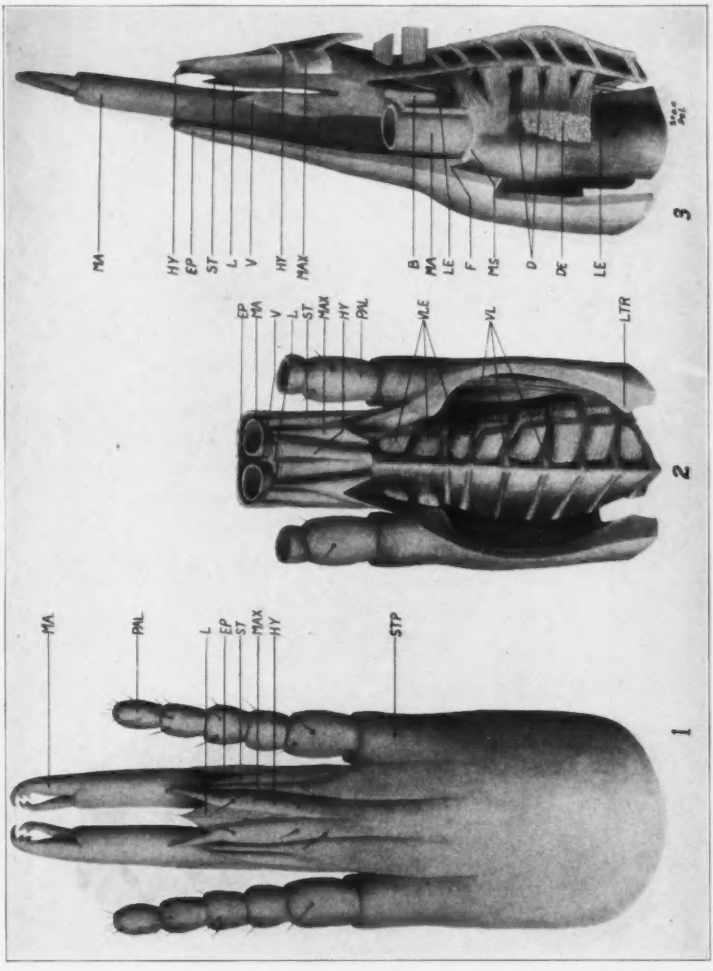
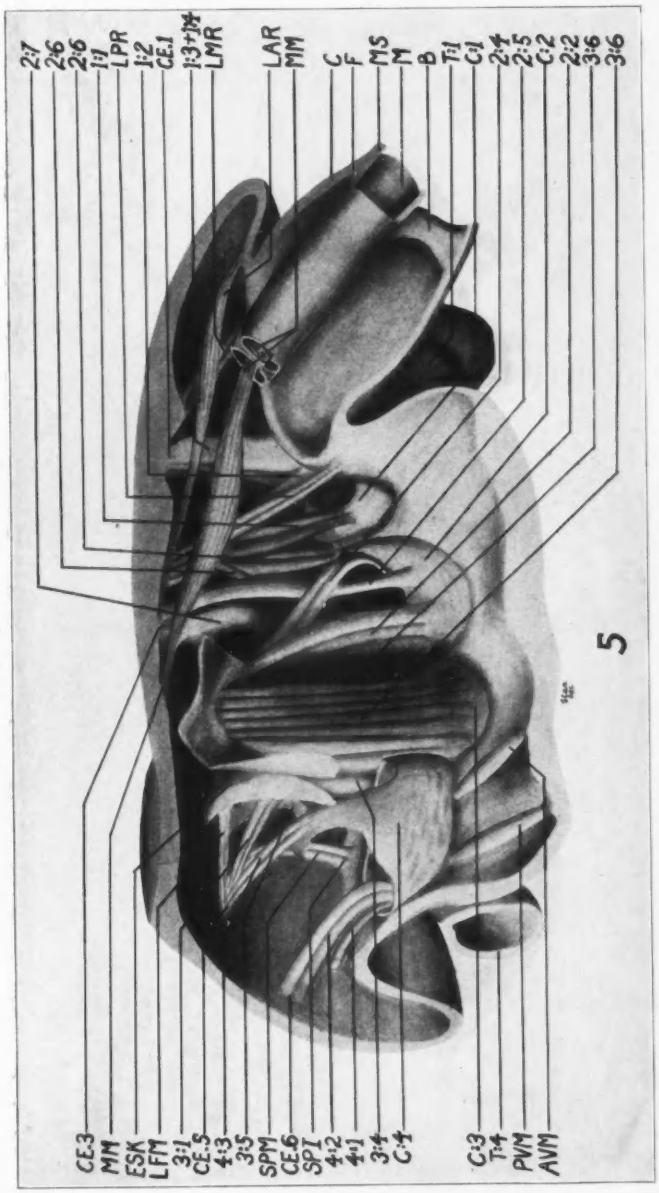
*Fig. 4 in series on plates removed to text as Text Fig. 1.—ED.

Mouth Parts of Laelaps
John Stanley

PLATE I.




2:7
2:6
2:6
1:1
LPR
1:2
CE.1
1:3+1:4
LMR
LAR
MM
C
F
MS
M
B
T:1
C:1
2:4
2:5
C:2
2:2
3:6
3:6
CE.3
MM
ESK
LFM
3:1
CE.5
4:3
3:5
SPM
CE.6
SPT
4:2
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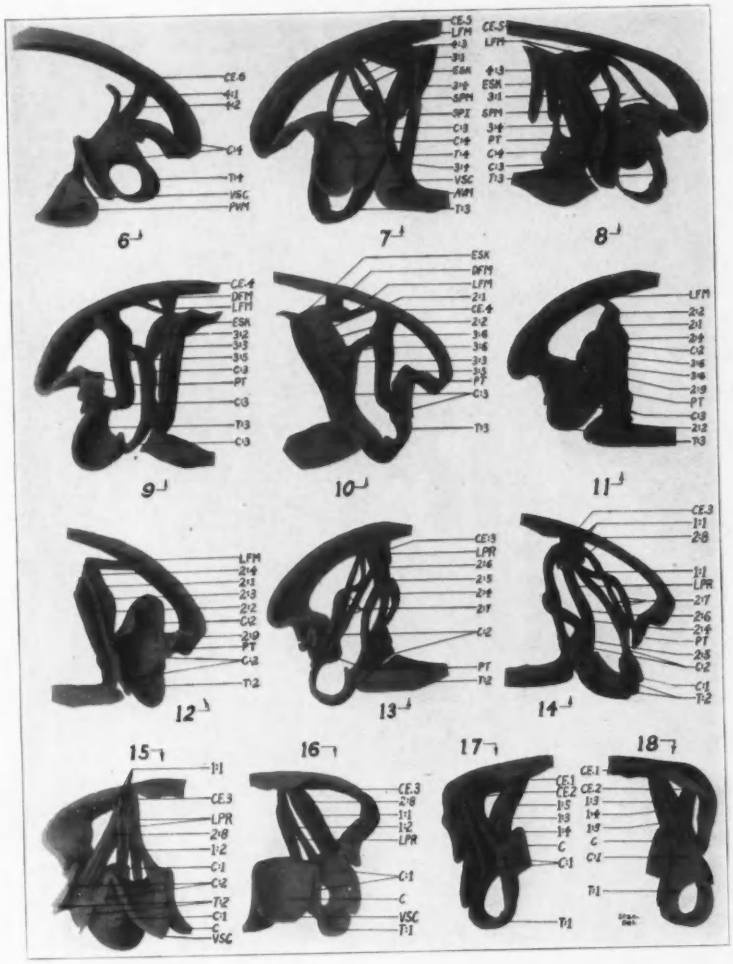
C:4
C:3
T:4
PVM
AVM
5

Mouth Parts of Laelaps
John Stanley

PLATE III.



DORMANCY IN REDUVIUS PERSONATUS (LINNAEUS).*

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INTRODUCTION.

The subject of dormancy of *Reduvius personatus* (Linnaeus) first aroused the interest of the writer when, while rearing this species in connection with studies of the biology of the Reduviidæ, it was observed that this insect apparently ceased development during the winter months, even though kept in heated quarters and supplied with the same food which permitted its development at other seasons of the year. A survey of the literature showed that others had observed this phenomenon, but had not attempted to explain it. De Geer (1) stated that this species passed the winter as an engorged nymph, without taking food; that its body became thin and flat; and that at the return of warm weather it again became active and recommenced feeding. Also Poujade (2) recorded the fact that he kept a nymph which he collected in August, 1887, until it molted and became an adult in June, 1888, thus living for ten months without undergoing more than one molt, its final one. This insect remained torpid during the winter and took no food.

It seems quite likely that this phenomenon is not limited to this species alone, but may be found in other insects of the same ecological group. Thus the clothes moth, *Tinea pellionella* Linnaeus; the buffalo carpet beetle, *Anthrenus scrophulariæ* Linnaeus; and the meal worms, *Tenebrio molitor* Linnaeus and *T. obscurus* Fabricius, have all been observed to become more or less inactive during the winter, though conditions of food and temperature have been suitable for their development.

There is a further possibility of a connection between dormancy in these insects and that exhibited by out-of-door

*This paper represents the results of work done during the tenure of a National Research Fellowship in the Biological Sciences, under the direction of Dr. R. N. Chapman. The writer wishes to acknowledge his indebtedness, and to express his appreciation, both to the Board of Fellowships in the Biological Sciences of the National Research Council, and to Dr. Chapman.

insects which are subjected to low temperatures and lack of food during the winter months. Many of the latter group cease activity while temperature is still high and food still abundant, and when these insects are maintained at relatively high temperatures with food present during the winter months, they still persist in their dormancy.

MATERIAL AND METHODS.

The material necessary for the working of this problem was assembled during the summer of 1928 at Lawrence, Kansas. Adults of both sexes of *Reduvius* were collected at a light trap and paired. The insects were confined in small cartons, and were fed daily on house flies which had been caught in a net and disabled before being introduced. Eggs were removed daily, weighed, and placed in a salve box for hatching. Upon hatching each young nymph was isolated in a small metal salve box, five-eighths inch high by one and one-half inches in diameter. It was found desirable to line the bottom of each box with a tightly fitting wad of heavy, unglazed paper, which served to give the bugs a foothold, and also to absorb excess moisture from food and excrement. Later, in work involving humidity, three-quarters inch holes were punched in the lids, and these openings covered with coarse silk bolting cloth, so that the atmosphere inside the box could come into equilibrium readily with that of the cabinet in which it was placed.

The nymphs also were fed house flies, since there was a large supply available. However, after the active work at St. Paul was begun, on September 3, a change of food was made to the larvæ of *Tribolium confusum* Duval, the confused flour beetle, an insect which is being used a great deal in experimental work by Dr. R. N. Chapman and his students. This insect proved to be a very satisfactory food supply for *Reduvius*, since it could be reared in any numbers desired, and in a short time, on common flour. The greatest objection to their use was that occasionally they would crawl upon, and kill or cripple a molting *Reduvius*.

Two methods were used in keeping a record of the development of the insects. The dates of occurrence of the molts were recorded, as is usual in rearing work. However, a more definite picture of the course of development than could be obtained by this method alone was desired, and so resort was made to the method of weighing individual insects at intervals, in order to determine the nature of growth between molts. The weighing was done with a chemical balance, the insect being enclosed in a stoppered weighing bottle. Since the range in weight is from .0004 gram in the newly hatched nymph, to .1438 gram in the largest adult recorded, anything less sensitive than a chemical balance would be unsatisfactory. The determinations were made at intervals of from one to seven days, and from these data growth curves were plotted for comparative study.

LIFE HISTORY OF REDUVIUS.

The later part of this report will be clearer if a seasonal life history of *Reduvius* is given here. This insect may be found as an adult from May to September, at least in the vicinity of Lawrence, Kansas. It may be found in dusty and unused portions of dwellings, or may be collected at bright lights, to which it is attracted. The eggs are laid at this season of the year in dusty corners, and hatch after an incubation period of from 15 to 25 days, within the range of summer temperature at Lawrence. The nymphs occupy the same habitat as do the adults and feed on insects also, according to the writer's observations, although Fabre (3) considered that they fed on animal fat, since he found them in the bone room of a slaughter house. The nymph molts five times,

TABLE I.

Oviposition and Incubation Record of One Pair of *Reduvius*, by Days and by Ten-day Periods.

DATE	NO. OF EGGS, 10-DAY TOTAL	WT. OF EGGS, 10-DAY AVERAGE. PER EGG—g	LENGTH OF EGG STAGE. 10-DAY AVERAGE	
5-24	.....	.....	.....	Male collected
6-7	.....	.....	.....	Female collected
6- 8 to 6-17	63	.000553	22.7	
6-18 to 6-27	57	.000546	18.4	
6-28 to 7- 7	79	.000523	15.7	
7- 8 to 7-17	89	.000530	15.5	
7-18 to 7-27	87	.000514	15.8	
7-28 to 8- 6	64	.000526	16.1	
8-2	.....	.....	.....	Male died
8-7	.....	.....	.....	Female died
Total and Avs.	439	.000531	17.3	

and at the fifth molt appears as a fully developed, winged adult. There is normally but one generation a year. It was because of the fact that I had observed what was apparently a dormant period during the nymphal life of this insect that I was attracted to this problem.

Oviposition and Incubation: Three pairs of adults only were assembled, and of these only one pair produced a large number of fertile eggs. The oviposition and incubation record of this pair is given in Table I, which probably includes the normal, complete adult life, since the female, when collected, was still soft of body, indicating recent molting.

Table I indicates that there are no abrupt changes in rate of egg production during adult life, since the differences observed in the ten-day totals are very likely due to seasonal variations in temperature. The differences in average weight per egg during the ten-day periods are also slight, although a general decrease in weight toward the end

of the oviposition period is indicated. The table also shows a progressive decrease in the length of the incubation period, very evidently correllated with seasonal temperature changes.

Early Growth: The growth of the first, second, and in a certain number of the group, the third instar, appeared to proceed without interruption. However, the variation in length of the first instar, from 1-1 to 65 days; and of the second instar, from 15 to 59 days, suggests the possibility of a short dormant period even in these early stages of development.

Appearance of Dormancy: The remainder of the insects in the third instar, together with others in the fifth, fourth and second instars, showed an almost complete cessation of development as winter approached, so that by the middle of November development had

TABLE II.

Number of Molts by Ten-day Periods of 159 Individuals of *Reduvius*, from Hatching, July 5–August 20, to November 16.

Date	No. of Molts	Date	No. of Molts
July 20–29	17	Sept. 18–27	60
July 30–Aug. 8	15	Sept. 28–Oct. 7	66
Aug. 9–18	26	Oct. 8–17	49
Aug. 19–28	28	Oct. 18–27	20
Aug. 29–Sept. 7	38	Oct. 28–Nov. 6	8
Sept. 8–17	42	Nov. 7–16	3

apparently ceased. An idea of the slowing down of development may be obtained from a study of Table II, which gives the record of molts of the whole population by ten-days periods from hatching to November 16.

Since the hatching period of the insects included in Table II extended from July 5 to August 20, the maximum number of molts could not be expected until about a month after the last date of hatching. The maximum once attained, it would be expected that this number would be kept up if there were no interruption to development. However, a study of the table shows that as the season progressed the number of molts decreased strongly until in the last ten-day period recorded only 3 individuals out of 159 molted. At the end of the period recorded, after which the group was broken up for rearing under various conditions of temperature and humidity, there were 4 individuals in the fifth nymphal instar, 50 in the fourth, 101 in the third, and 4 in the second.

EXPERIMENTS.

Light on the nature and occurrence of the dormant period is thrown by the weight records, which, when plotted against time, take the form of growth curves. A series of these, representing insects kept throughout their development under room conditions, as a check, is shown in Figure 1.

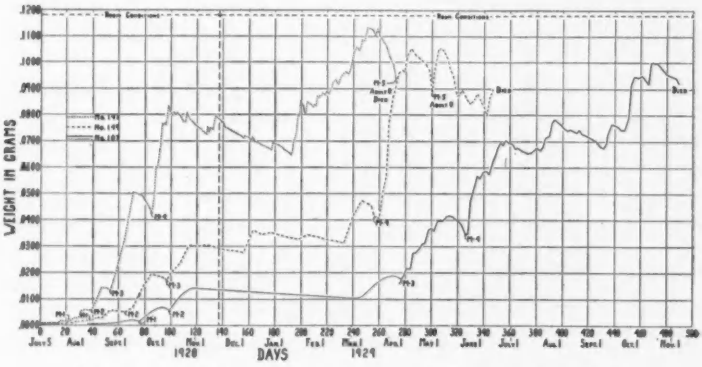

FIGURE 1. Growth of three individuals of *Reduvius personatus* at room conditions.

In Figure 1, as in all other growth curves included in this report, weight on the vertical axis is plotted against time on the horizontal axis. Molts are indicated by the designations M-1, M-2, etc. Heavy lines, dashes and dots are used for weights actually determined. Light lines, dashes and dots are used for the portions of the curves where weight was not actually determined. These portions are exact with respect to the horizontal axis, but approximate with respect to the vertical axis.

Insect number 147 may be considered as a representative of the 4 insects which were in the fifth instar at the time of appearance of dormancy. The curve of this insect shows a relatively uninterrupted course of development, with interruptions only for molts, through the fourth instar and slightly beyond. However, a decided flattening of the growth curve, occurring soon after the fourth molt, shows that some hindrance to further development is operating.

The early part of the growth of number 149 may be considered as typical of the 50 insects which reached the fourth instar before dormancy appeared. In this case the early growth is less rapid, and the fourth molt is not made until the spring following hatching. Again there is a definite flattening of the curve of growth, indicating interruption.

Number 107 may be considered as typical of the 101 insects which reached only the third instar before dormancy appeared. Here the early growth is still slower, and the interruption to development occurs after the second molt, the third molt taking place after the dormant period.

These curves show a rather surprising variation in rate of growth in this species. Also, the occurrence of an interruption during the several periods of development is not what would be expected in inherent dormancy. That is, in all the commonly accepted cases of inherent dormancy, the dormancy is associated with a definite stage of development, and does not occur elsewhere in the life cycle. In fact, the occurrence of the dormancy in this case at a certain season of the year, without regard to the stage of development, strongly suggests the possibility of some seasonal factor being responsible for the inception of dormancy.

Growth of Similar Insects: At this point it is well to consider the growth records of other insects which may logically be expected to show development similar to that of *Reduvius*. For purposes of comparison the growth records of two other insects, *Sinea diadema* (Fabricius), and *Cimex lectularius* (Linnaeus), have been recorded and growth curves plotted. The former is of the same family as *Reduvius*, so may be considered as taxonomically similar, as well as similar in regard to food and method of feeding, though a field insect. The latter, the common bed bug, is a household insect, and may be considered as similar ecologically.

These curves show that the growth between molts, as in *Reduvius*, consists of a comparatively long period of rather rapid increase followed by a short period of decrease in weight preceding the molt. There is less individual variation than in *Reduvius*. The most important thing for our consideration, however, is that development from egg to adult is continuous, there being no flattening of the curve of growth previous to the

appearance of the adult at least. It should be explained here that the term "adult" is used to refer to the fully winged individual which appears after the last molt, and is not neces-

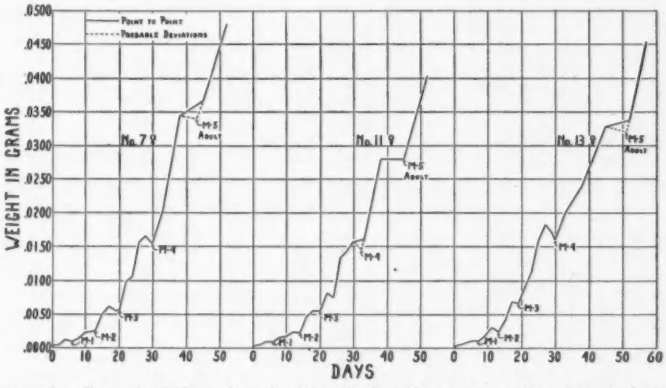

FIGURE 2. Growth of three female *Sinea diadema* from time of hatching to beyond final molt to adult, July 6 to August 27, 1928.

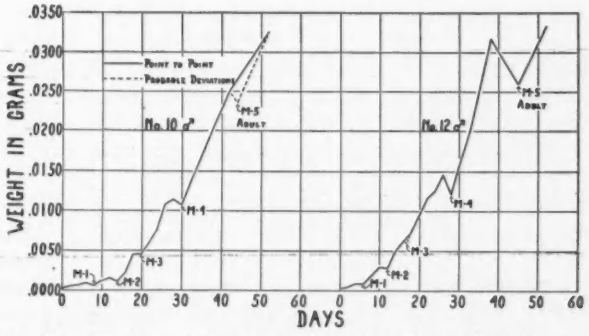

FIGURE 3. Growth of two male *Sinea diadema* from time of hatching to beyond final molt to adult, July 6 to August 27, 1928.

sarily limited to the sexually mature form. In this species there is apparently considerable growth after the final molt.

The curves of growth of the bed bug are quite different in appearance from those of the Reduviidæ, *Reduvius* and *Sinea*. The bed bug feeds only once for each stage of development, and after this meal, remains hidden until after the molt occurs.

Soon after the molt it is ready to feed again. While the growth curve of the bed bug does not show a continuous rise, nevertheless the general course of development is continuous.

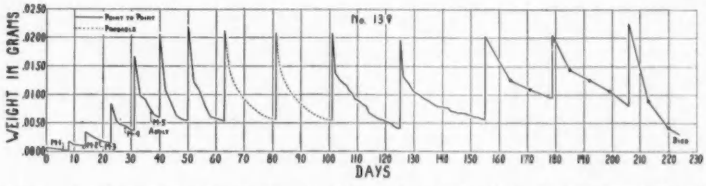

FIGURE 4. Growth of single female *Cimex lectularius* from hatching to death, June 6, 1928, to January 16, 1929.

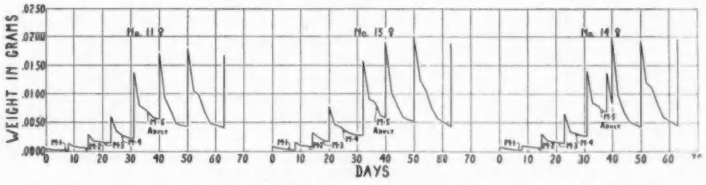

FIGURE 5. Growth of three female *Cimex lectularius* from hatching to beyond final molt to adult.

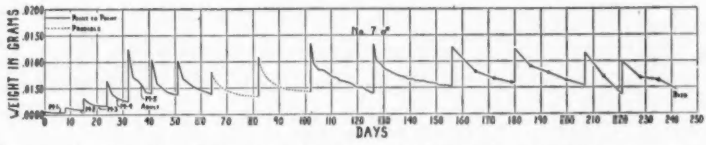

FIGURE 6. Growth of single male *Cimex lectularius* from hatching to death, June 5, 1928, to February 29, 1929.

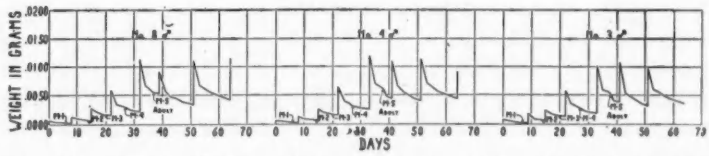

FIGURE 7. Growth of three male *Cimex lectularius* from hatching to beyond final molt to adult.

Thus, the essential thing shown by the growth curves of *Sinea diadema* and *Cimex lectularius* is that the cessation of growth observed in *Reduvius* is a developmental peculiarity common neither to the systematic, nor to the ecological groups to which *Reduvius* belongs.

Recovery From Dormancy under Various Combinations of Temperature and Humidity: Because of the indication of a possible seasonal influence in the dormancy of *Reduvius*, as shown in the molting records and growth curves, it was decided to determine the effect of various temperatures and humidities on the dormancy. Six combinations were possible for a part of the time at least. Two temperature and humidity control cabinets manufactured by the Carrier Engineering Corporation were maintained at 27° C., 75% relative humidity, and 27° C., 50% relative humidity respectively. A third cabinet without humidity control was held at 27° C. The intention was that this cabinet would be in equilibrium with the atmosphere of the room as far as humidity was concerned. However, in the determinations made it was found to vary from room humidity, 20-30% relative humidity, to as high as 50% relative humidity. However, the average was decidedly lower than that of the 50% Carrier cabinet, and it may be considered as forming the third and lowest of a series of three humidities all held at 27° C. A fourth cabinet was held at 32° C., and at 75% relative humidity. A fifth was held at 22° C., 75% relative humidity. Necessary repairs caused the interruption of the work in the last mentioned cabinet. A sixth group of insects was maintained at room conditions, where the temperature varied 2 or 3 degrees above and below 22° C., and the relative humidity from 20 to 30%.

The results of submitting third instar insects which had apparently become dormant at room conditions before November 19, to these various combinations of temperature and relative humidity, are shown in Table III.

Table III shows that the insects of the first four groups recovered from dormancy to the extent of molting in a comparatively short time after subjection to the changed conditions. Also the recovery appears to be in response to higher temperature, and not in response to higher humidity. This is best shown in the series of insects all maintained at 27° C., but at three different humidities, in which recovery takes place in all three after approximately the same length of time, 16.1, 18.1 and 15.5 days. Thus it would appear that the decrease in relative humidity which accompanies the advance of winter has nothing to do with the inception of dormancy in this case. Nor is it possible to conclude that dormancy became necessary

because temperature was not high enough to permit active development, since development did take place at the temperature at which dormancy appeared, previous to the appearance of dormancy. The most logical explanation of the results is that dormancy appeared as the result of some inherent condition, and was broken by the stimulus of higher temperature. Possibly dormancy would not have appeared during the third instar at the higher temperature, but the tendency to dormancy would nevertheless have been present. Since the experiment

TABLE III.

Recovery of Third Instar *Reduvius* which had Become Dormant at Room Conditions, When Subjected to Various Combinations of Temperature and Humidity.

CONDITIONS		No. of Insects	Av. No. Days Since Last Molt	Died	Molted	Av. No. Days to New Molt	Tot. Length of 3rd Inst. Av. No. Days
Temp	Rel. Hum.						
32° C.	75%	15	40.4	1	14	11.9	52.4
27° C.	75%	17	44.6	1	16	16.1	60.7
27° C.	50%	15	44.7	1 (Acc.)	14	18.1	62.8
27° C.	Uncontr.	15	42.7	0	15	15.5	58.1
22° C. (17 days only)	75%	19	35.2	0	4	3.7	39
32° C. (17 days previous in 22° C., 75% R. H.)	75%	15	59.6	1	14	10.5	70.1
Check (Room conditions)		17	41.4	2 (Acc.)	15	117.6	159

involving insects maintained at 22° C., 75% relative humidity was interrupted after 17 days, the results here are inconclusive. Four out of 19 insects completed their development of the instar and molted in an average time of 3.7 days. Since the length of time necessary for the molt was so much shorter than at the higher temperatures it is considered that these individuals probably had not become completely dormant, and hence did not satisfy the conditions of the experiment. The remainder of these insects, when placed at 32° C., 75% relative humidity, molted in 10.5 days, showing little or no effect of the preceding 17 days at 22° C., 75% relative humidity in producing relief from dormancy. The remaining 17 insects, held at room con-

ditions as a check, did not make the third molt until after an average period of 117.6 days.

Similarly fourth instar insects which had become dormant at room conditions were subjected to combinations of different temperatures and humidities, in an attempt to discover the relation of these factors to dormancy. The results of these experiments are summarized in Table IV.

The results here are similar to those shown in Table III, in that those maintained at the higher temperatures all recovered

TABLE IV.

Recovery of Fourth Instar *Reduvius* which had Become Dormant at Room Conditions, when Subjected to Various Combinations of Temperature and Humidity.

Conditions		No. of Insects	Av. No. Days Since Last Molt	Died	Molted	Av. No. Days to New Molt	Tot. Length of 4th Inst. Av. No. Days
Temp.	Rel. Hum.						
32° C.	75%	6	36.7	3	3	27.6	64.3
27° C.	75%	10	37.4	2	8	27.7	65.1
27° C.	50%	6	33.7	2	4	27.7	61.5
27° C.	Uncontr.	6	38.2	1	5	26.2	64.4
22° C. (39 days only)	75%	13	18.5	0	2	33	51.5
Room Conditions (39 days previous at 22° C., 75% R. H.)		11	98.4	3	8	83.1	181.6
Room Conditions (Check)		10	52.6	1	9	123.9	176.5

and molted in approximately 27 days, while those kept at original conditions as a check did not recover until after having passed through an average dormant period of 123.9 days. Recovery and molting required longer than in the third instar. There is no indication in the results that recovery requires less time at 32° C. than at 27° C., though the numbers are so small that this may not be of significance. The death rate is higher than in the third instar, especially at the higher temperatures. This may be explained on the assumption that some of the fourth instar individuals are more completely dormant than others, so completely so that the stimulus of higher temperature fails to break their dormancy, and since high temperature and dormancy are incompatible, causes their death.

Growth of Fourth and Fifth Instar Reduvius at Various Combinations of Temperature and Humidity: After the recovery, under the influence of higher temperatures, of the greater number of insects which had become dormant at room conditions, a study of the growth of the fourth and fifth instars at various combinations of temperature and humidity, and of the occurrence of other dormant periods in the life cycle was made.

The data for the growth of the fourth instar are presented in Table V.

TABLE V.

Growth of Fourth Instar *Reduvius* at Various Combinations of Temperature and Humidity.

Conditions		No. of Insects	Length of 3rd Instar. Days Av.	Died	Molted	Length of 4th Instar. Days Av.	Length of 3rd and 4th Instars
Temp.	Rel. Hum.						
32° C.	75%	20	58.1	3	17	41.8	99.9
27° C.	75%	18	59.6	1	17	28.8	88.4
27° C.	50%	16	69.2	4 (Acc.)	12	32.7	101.8
27° C.	Uncontr.	14	57.7	1	13	33.3	91
Room Cond. (A) (Check)		12	158.1	3	9	65.2	223.3
Room Cond. (B) (Check)		13	29.3	1 (Acc.)	12	171.5	200.7

Table V shows that at the higher temperature of 32° C. and 27° C. the development of *Reduvius* during the fourth instar proceeds without the intervention of a long dormant period at all of the conditions of humidity investigated. The length of time necessary for the growth of the instar was longer at 32° C. than at 27° C., and the death rate was higher at the higher temperature. Of those maintained at room conditions, those which had passed through the third instar in a comparatively short time (Group B), entered a dormant period during the fourth instar; while those which had already passed through a long dormant period in the third instar (Group A), completed the development of the fourth instar without undergoing a long dormant period.

From these results we may conclude that the stimulation of higher temperature is effective in the growth of the fourth,

as well as in recovery from dormancy in the third and fourth instars; and that at lower temperatures dormancy during the third instar eliminates the necessity for dormancy during the fourth instar.

Table VI shows that fifth instar insects maintained at the higher temperatures of 32° C. and 27° C. were unable to complete the growth of this instar without the intervention of a dormant period. Of those maintained at 32° C., 8 out of 14 were killed accidentally, and the other 6 had died previously. Of those maintained at 27° C., 75% relative humidity, 10 out of 17 died

TABLE VI.

Growth of Fifth Instar *Reduvius* at Various Combinations of Temperature and Humidity.

CONDITIONS		No. of Insects	Length of 3rd Days Av.	Length of 4th Days Av.	Length 1-4 Days Av.	Died	Molted	Length of 5th Days Av.	Length 1-5 Days Av.	Av. Max. Weight Grams
Temp.	R. H.									
32° C.....	75%	14	51.2	41.9	151.1	14	0	.....	.....	.....
27° C.....	75%	17	51.7	40.1	145.3	10	7	143.3	288.6	.0926
27° C.....	50%	16	62.2	34.2	158.3	10	6	129.5	287.8	.0913
27° C.....	25%	13	57.6	36.5	156.5	5	8	87.9	244.4	.1102
Room Cond. (Check-A).....		7	21	41.7	105.7	4	3	190.3	296	.1116
Room Cond. (Check-B).....		16	32.6	163	244.7	3	13	56.7	301.5	.1034
Room Cond. (Check-C).....		6	167.6	64.2	286.5	6	0	.....	478.4 (Inc.)	.0940

and the remainder molted to the adult after an average period of 143.3 days. Of those at 27° C., 50% relative humidity, 10 out of 16 died, and the remaining 6 transformed after an average period of 129.5 days. Those maintained at 27° C., 25-% relative humidity had a death rate of 5 out of 13, the remaining 8 transforming after an average period of 87.9 days. This group completed its development in the shortest time, with the lowest death rate, and the greatest maximum weight attained, of any of the three groups maintained at the same temperature, but different humidities. This indicates that low relative humidity is favorable to successful dormancy in this insect. The high death rate in this and other groups maintained at high temperature is again an indication of the incompatibility of high temperature with dormancy.

Of the group maintained at original conditions of 22° C., room humidity, those which had completed their earlier development without a long dormant period (Group A), became dormant during the fifth instar; of those which had passed through a dormant period in the fourth instar (Group B), 12 out of 16 passed through the fifth instar without a long dormant period, while the remaining 4 again became dormant during the fifth instar, 3 dying before transformation; those which had passed through a dormant period in the third instar, but not in the fourth (Group C), again entered a long dormant period in the fifth instar. Thus, the only group that escaped a dormant period in the fifth instar was the group which had just recovered from a dormant period in the fourth instar, and even some of these also became dormant in the fifth instar.

These results give further evidence to show that dormancy in *Reduvius* is inherent in nature, rather than induced by environmental conditions of temperature and humidity, since dormancy occurred in the fifth instar at the same conditions of temperature and humidity which allowed active development in the third and fourth instars. There is a very decided indication that dormancy is more intense in the later stages of development, being most intense during the fifth instar.

Growth Curves: To give a more complete picture of the occurrence of dormant periods in the life cycles of insects reared under various conditions of temperature and humidity, growth curves of representative insects are given.

Figure 1 is of the development of three insects kept at room conditions as a check. These insects became dormant at three different points in their development, one in the fifth, one in the fourth, and one in the third instar. Number 147 became dormant during the fifth instar, lost weight during the winter, recovered slowly during late winter and early spring, and finally molted to the adult on the first of April. Number 149 became dormant in the fourth instar, made the fourth molt in the spring, and then very quickly completed the growth of the fifth instar and molted to the adult. In this case, then, dormancy during the fourth instar made dormancy during the fifth instar unnecessary. Number 107 spent the winter in dormant condition in the third instar, recovered and made the third molt in the spring, completed the growth of the fourth instar without interruption, but entered a second dormant

period during the fifth instar. The life of this insect, ended without reaching the adult stage on November 6. In this case dormancy during the third instar replaced dormancy in the fourth instar, but did not eliminate dormancy during the fifth instar. It is interesting to note that in this insect dormancy occurred during the summer months.

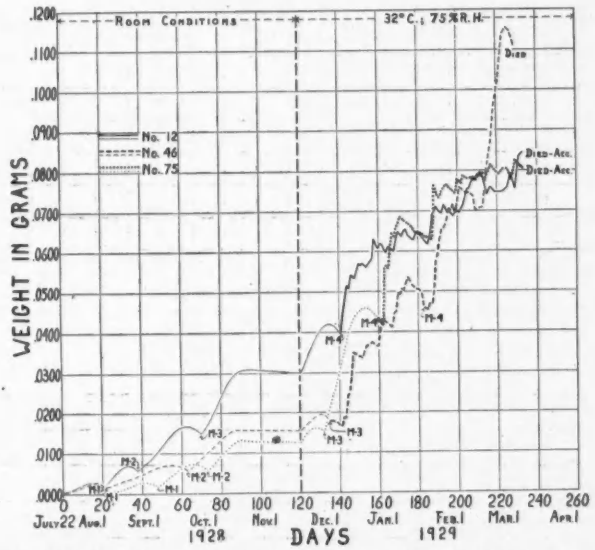

FIGURE 8. Growth of three individuals of *Reduvius* which had become dormant at room conditions, and were later subjected to conditions of 32° C., 75% relative humidity.

Number 12, in the fourth instar at the time of change of conditions, recovered from dormancy under the stimulus of higher temperature, molted to the fifth instar, and passed nearly a hundred days in the fifth instar before being killed accidentally. Numbers 46 and 75 had become dormant in the third instar, and were stimulated by higher temperature to make the third molt, and also to complete the development of the fourth instar, but apparently could not complete the development of the fifth instar without passing through a dormant period. The whole group being maintained at these conditions was killed accidentally.

Number 91, in the fourth instar at the beginning of the experiment, recovered and molted to the fifth instar, but spent

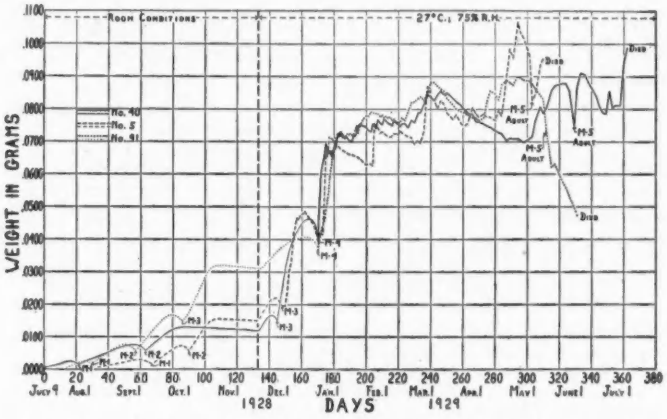

FIGURE 9. Growth of three individuals of *Reduvius* which had become dormant at room conditions, and were later subjected to conditions of 27° C., 75% relative humidity.

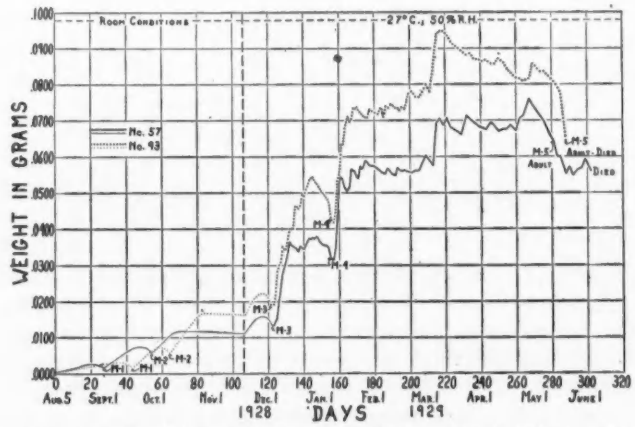

FIGURE 10. Growth of two individuals of *Reduvius* which had become dormant at room conditions, and were later subjected to conditions of 27° C., 50% relative humidity.

a comparatively long time in the fifth instar before molting to the adult. Numbers 5 and 40 were in the third instar at the beginning of the experiment, recovered and molted to the fourth

instar, completed the growth of the fourth instar without interruption, but became dormant during the fifth instar, finally molting to the adult.

In the case of the two insects shown in the above figure, recovery and molting took place soon after subjection to the conditions of the experiment, the growth of the fourth instar was completed without interruption, but dormancy appeared in the fifth instar.

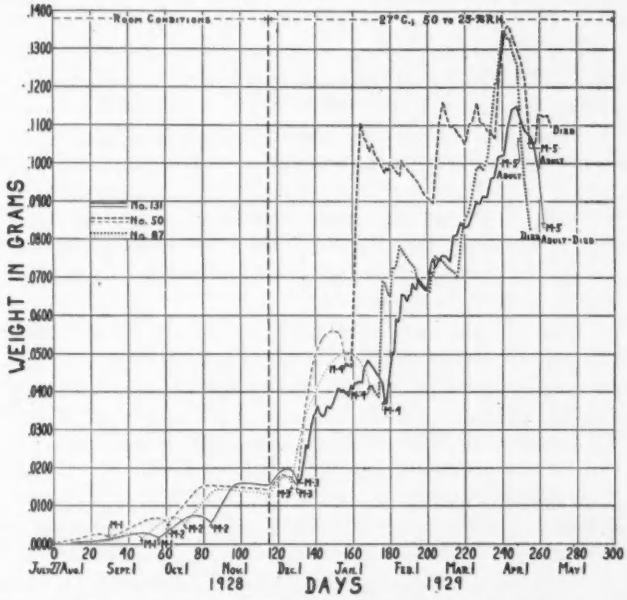

FIGURE 11. Growth of three individuals of *Reduvius* which had become dormant at room conditions, and were later subjected to conditions of 27° C., 50 to 25—% relative humidity.

The insects shown in Figure 11, all in the third instar at the time of subjection to experimental conditions, recovered from dormancy and made the third molt, completed the growth of the fourth instar without interruption, but passed through a short dormant period in the fifth instar before molting to the adult. The development of insects under these conditions differed from development at the same temperature, but higher relative humidity, in that dormancy during the fifth instar did not last so long, and the maximum weight attained was greater.

DISCUSSION OF RESULTS

A study of the growth of the early stages of *Reduvius*, before the appearance of dormancy, shows that there is a great deal of variation in rate of development. This variation, since it can not be accounted for by the conditions of rearing, must be considered as due to inherent individual variation in rate of growth, probably connected with variation in rate of metabolism. This variation in rate of development seems very significant in relation to the irregular appearance of dormancy later in the life cycle. In fact, it seems quite likely that the extreme length of the early instars may be due to the appearance of a short dormant period.

The cessation of active development indicated by the decline in number of molts shown in Table II, and by the growth curves in Figure 1, is a phenomenon of primary interest in this study. There are two possible explanations for this cessation: first, that it is due to some environmental factor; second, that it is due to an inherent dormancy appearing at several places in the life cycle.

The seasonal factors most likely to be of importance are food, temperature and humidity. In this case food can not be of importance, since the insects were supplied continually with the same food which allowed active development earlier in the year. Temperature, also, varied only slightly from that which had allowed active development. The humidity of the atmosphere, however, varied a great deal, declining as winter approached, in general correllation with the appearance of dormancy.

If the cessation in development is due to inherent dormancy, the dormancy is one that appears irregularly at several points in the live cycle, which is unusual in insects. However, Calvert (4), in studying the growth of the dragon fly, *Nannothemis bella* (Uhler), found that two of the insects with which he was working transformed to the adult stage after having spent two winters in a dormant condition, while a third individual transformed only after having spent three winters in dormancy. These insects were furnished food continually, and were not subjected to extreme variations in temperature (89° to 50° F.). Dr. Calvert says of their condition: "From January to April, 1926, the *bella* larvæ were

very sluggish, this feature being more marked in numbers 56 and 58 than in the other two. Responses of number 56 to touch stimuli on March 14 were very slow and slight, but even in this individual the degree of sluggishness varied from week to week." It may be, then, that the irregular appearance of dormancy is more common in nature than is known. The individual variation in rate of development observed in the earlier stages of *Reduvius* indicates the possibility, at least, of an individual variation in the stage at which dormancy appears.

The experiments involving recovery of third and fourth instar insects which had become dormant at room conditions, when subjected to various combination of temperature and humidity, indicate that humidity could not have been the determining factor in the inception of dormancy, since recovery takes place in response to higher temperatures, rather than to higher humidity. Neither can we conclude that the lower temperature at which dormancy appeared was responsible for its inception, since it has already been shown that active development did take place at that temperature. We are led, then, to the conclusion that dormancy in *Reduvius* is inherent, but that it may be broken during the third and fourth instars by the stimulation of higher temperature. Jucci (5) and others have shown that submersion in dilute acid, friction, extreme temperatures, etc., are effective in producing the hatching of dormant silk worm eggs, and to the writer this seems to be a similar phenomenon.

Growth of the fourth instar proceeded without the interruption of dormancy at the higher temperatures of 32° and 27° C., but at 22° C. those insects which had not passed through a dormant period in the third instar became dormant in the fourth instar. Dormancy during the third instar, however, made dormancy during the fourth instar unnecessary.

The growth of the fifth instar was not completed without interruption even at the higher temperatures. All of the insects which had not passed through a dormant period in the fourth instar, and even some of these also, became dormant during the fifth instar, regardless of temperature. Thus the stimulus of higher temperature, which caused the breaking up of dormancy in the third and fourth instars, and caused the uninterrupted growth of the fourth instar, was not effective in producing the continuous development of the fifth instar.

This is rather direct evidence that dormancy in *Reduvius* is inherent in nature. It also shows that dormancy in the fifth instar is more intense than in the third and fourth instars. The data on the growth of the fifth instar also give rather decided evidence to the effect that low humidity is favorable to successful dormancy in this insect.

Several theories attempting to explain the fundamental nature of inherent dormancy have been advanced. Of these, Roubaud's (6) theory of uremic intoxication appears to fit the observed phenomena better than any other. According to Roubaud, the dormancy is due to the accumulation of unexcreted urates, which have a toxic effect and prevent further development. Roubaud found that certain species recovered from dormancy when subjected to stimuli, such as heat, pricking, bleeding, etc., while others did not. He concluded that the dormancy was less intense in the former cases, and more intense in the latter. Roubaud gave the conditions of successful dormancy as low temperature or low humidity, since either retards the rate of metabolism, but allows the excretion of urates to continue. In the above results we see that low humidity was more successful than higher humidities in relieving dormancy, and that the death rate was high in dormant insects at high temperatures and humidities. The results of this paper can not be considered to substantiate Roubaud's theory, but the agreement in the points mentioned is worthy of note.

CONCLUSIONS

1. There is a distinct individual variation in rate of development in *Reduvius*, evident throughout the whole course of nymphal development.

2. This species may enter into a state of prolonged dormancy during the third, fourth or fifth nymphal instars, and probably into shorter periods of dormancy in the first and second instars.

3. The study of the growth of other insects, *Sinea diadema* (Fabricius) and *Cimex lectularius* (Linnaeus), shows that this dormancy is characteristic of neither the taxonomic, nor the ecological groups to which *Reduvius* belongs.

4. The dormancy is of the obligatory type, that is, produced as a result of some inherent, physiological condition, and not induced by unfavorable external conditions of development.

5. The insect, when dormant, is subject to the influence of environmental factors. Dormancy of the third and fourth instars is broken by the stimulus of higher temperatures, though that of the fifth instar is not. Dormancy of the fifth instar (also that of the third and fourth instars, possibly) is completed more successfully (shorter, with lower death rate, and with higher maximum weight attained) at low, than at high humidity.

6. Dormancy is progressively more intense in the later stages of nymphal development.

7. While the results obtained by no means completely substantiate Roubaud's theory of uremic intoxication, the assumption of the truth of this theory permits the explanation of the phenomena observed.

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ADDITIONAL NOTES ON THE NATURAL ENEMIES OF THE IRIS BORER, MACRONOCTUA ONUSTA GROTE (LEPIDOPTERA).

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In an earlier paper[2] the writer reported on the natural enemies found attacking the Iris borer, *Macronoctua onusta* Grote, at Madison, Wisconsin, in 1928. The studies were continued in 1929, and the following notes are intended to constitute a sequel to the former. An unusually heavy infestation of several years standing furnished the opportunities for these studies. Data have been gathered which offer a basis for comparing the development of the infestation of 1929 with that of 1928, and suggest the influence natural enemies may have on the fluctuation of the population.

The Iris at the station occupies nine nursery rows of about forty meters each in length. The occasional removal of a few plants and the cultivation of the soil between the rows constitute the chief disturbances by man in recent years. Each season the dead and discolored remains of the Iris plants have not been removed or destroyed, providing conditions in this respect favorable for the development of the infestations.

By May 15, the mines of the young borers were numerous in the leaves of the Iris. It was again noted that the mines were most numerous in the leaves of plants belonging to the Apogon group. Early in June, the borers had nearly all extended their burrows well down between the ensheathing lower halves of the leaves; and from all appearances the infestation was developing on a parallel with that of 1928. Later in the season however, it became apparent that the population was being reduced in numbers, and that the borers were not nearly so numerous as they had been at a similar period in 1928.

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[1]These data were gathered while the writer was employed as Field Entomologist for the Wisconsin Department of Agriculture and Markets.

[2]Breakey, E. P. Notes on the Natural Enemies of the Iris Borer, *Macronoctua onusta* Grote (Lepidoptera). Ann. Ent. Soc. America, XXII, pp. 459–464, 1929.

Experience had taught that larval development would be nearing completion early in August. On August 4, collections were again made with the hope of securing a census of the natural enemies which would be attacking *M. onusta* at this stage. Only by persistent effort were the needed one hundred specimens secured. A comparison of the infestations of the two seasons at this period can be obtained from the following: In 1928, a section from a row of Japanese Iris about five meters in length yielded one hundred seventy-two specimens from the earth near the plants, while one year later one hundred specimens were obtained from the entire nursery only by persistent effort. It is regretted that so little has been learned of the enemies which attack the caterpillars earlier in life.

It was quite generally held that the summer of 1929 had been drier than usual. The writer had noted that instead of finding an accumulation of wet excrement in the burrows of the caterpillars, as was to be expected, the usual experience was to find the contents of the burrow quite thoroughly dried out. This, together with the dry condition of the soil encountered while making collections, suggested that a comparison of the rainfall for the two seasons might be helpful in accounting for the decrease in the population of *M. onusta* and the apparent change in the constituency of the parasitism. The following summary is based on the Monthly Meteorological Summaries issued by the local office of the U. S. Weather Bureau.

RAINFALL IN INCHES.

	May	June	July	August
Normal	3.85	3.76	3.88	3.21
1928	—0.88	+2.57	—1.24	+1.48
1929	—2.54	+0.59	+4.14	—2.34

\+ Excess.
— Deficiency.

It would be difficult to evaluate the effect rainfall, or the lack of it, may have had on the development of the infestation or on the success of the various parasites. The last seventeen days of July, 1929 were without rainfall, with one notable

exception. On July 23, 24, 25 and 26, 4.93 inches of water fell. This was followed by a deficiency in August of 2.34 inches. Conditions were apparently ideal for periods of drought. This is a case for atmometry and cannot be adequately explained without such data. Such conditions of dryness would not contribute to the success of species with habits such as those of *Muscina stabulans* Fall. and *Myiospila meditabunda* Fab., while species with habits such as those of *Masicera senilis* Mg. would be only indirectly affected.

One hundred caterpillars of *M. onusta* were collected and accounted for, using the same procedure as in 1928. Of this number, eight were destroyed by parasitic Diptera, six by parasitic Hymenoptera, and one by a species of parasitic fungus. It will be noted that Diptera were apparently responsible for about the same degree of parasitism as in 1928. Evidence was obtained which indicates that Diptera may have been responsible for an even greater percentage of parasitism. The shrunken remains of twelve caterpillars were found having the appearance of those recently abandoned by parasite maggots. Only one of these figures in the above data however, as it was the only one having the puparium of the fly associated with it in an unquestionable manner. Since no Hymenoptera or fungi were found attacking the caterpillars in 1928, it is interesting to find them occupying such an important place in the parasitism of *M. onusta* in 1929.

The following notes are presented for the purpose of suggesting the extent to which each species may be considered a natural enemy of *M. onusta*.

HYMENOPTERA[3]

The first Hymenoptera appeared in the cages on August 29 and the last on August 31. In each instance the host had been destroyed in the pupal stage. The following species issued from the chrysalids of *Macronoctua: Amblyteles laetus* (Brullé), *A. rubicundus* (Cress.) (Ichneumonidæ) and *Psychophagus omnivorus* (Walk.) (Pteromalidæ).

[3]The writer wishes to thank Messrs R. A. Cushman and A. B. Gahan, of the U. S. National Museum, for their services in determining the identity of the Hymenoptera.

Amblyteles laetus (Brullé).

This solitary parasite was apparently the most important of the Hymenopterous enemies of *M. onusta* in 1929. Adults of this insect issued from three percent of the specimens under observation. The chrysalis of the host was used in lieu of a cocoon in which to undergo transformation. This species is known to be a parasite of *Papaipema spp.*, and the writer has secured it from pupæ of *Pyrausta ainsliei* Hein., the smart weed borer, at Madison. The pupæ of *Pyrausta* were of the overwintering generation. It is evident that *A. laetus* has two generations a year and can use *Macronoctua* as the summer host.

Amblyteles rubicundus (Cress.)

One specimen of this species issued from a chrysalis of the host. From all appearances it is very similar in its habits to *A. laetus*.

Psychophagus omnivorus (Walk.)

Two pupæ of the host were destroyed by this multiple parasite, sixteen specimens issuing from one and thirty from the other. This species was also an important enemy of *Achatodes zeæ* (Harris), the spindle worm, at Madison in 1929.

DIPTERA[4]

The first Diptera appeared in the cages on August 24. Later in the season, when carefully removing the contents of the cages preparing to put them away for the winter, three puparia from which flies had not yet emerged were found in the sand. These were given suitable care and on April 26, 1930 two small flies made their appearance. The following species were attacking *Macronoctua* in 1929: *Masicera senilis* Mg. (Muscidæ) and *Sarcophaga helicis* Tns. (Sarcophagidæ).

Masicera senilis Mg.

This fly was the most important parasite of *Macronoctua* at Madison in 1929, destroying five percent of the caterpillars under observation. The interesting habits of this parasite have been discussed by the writer in the earlier report.

[4]The writer is indebted to Dr. J. M. Aldrich, of the U. S. National Museum, for determining the Diptera.

Sarcophaga helicis Tns.

Two specimens of this fly emerged on April 26, 1930. Dr. Aldrich states in correspondence, "This is a species which sometimes attacks living insects, but in many instances deposits its maggots upon dead ones; so it has quite a diversity of habit and seems not to be particular about the species of insect, being able to develop in almost anything."

FUNGI

Among the caterpillars collected was one which had the appearance of a well preserved mummy. It was cold, stiff and firm to pressure. Sensing that it had not died from ordinary causes it was preserved for future observation. On the following day its body was completely covered with a mat of white hyphæ. Later it was sent to Prof. Roland Thaxter for examination. The fungus proved to be still viable and he reported that it was the typical *Beauveria* (Sporotrichum) *globulifera* Speg. This fungus attacks a great variety of insects and is being used by the Gypsy Moth Laboratory against the satin moth.

SUMMARY OF KNOWN PARASITES OF *MACRONOCTUA ONUSTA* GROTE.

DIPTERA.

Muscina stabulans Fall.
Muscina assimilis Fall.
Myisopila meditabunda Fab.
Sarcophaga cimbicis Tns.
Sarcophaga latisterna Park.
Sarcophaga helicis Tns.
Masicera senilis Mg.

HYMENOPTERA.

Apanteles militaris Walsh.[5]
Amblyteles jucundus (Brullé)[5]
Amblyteles laetus (Brullé).
Amblyteles rubicundus (Cress.)[6]
Amblyteles brevicinctor (Say).
Psychophagus omnivorus (Walk.)

FUNGI.

Beauveria (Sporotrichum) *globulifera* Speg.

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[5]Reported by H. F. Dietz from Indiana.

[6]Reported by E. N. Cory from Maryland. This species' presence at Madison was established when a specimen issued from a chrysalis of *Achatodes zeae* (Harris) on July 14, 1929.

THE POST-EMBRYOLOGICAL DEVELOPMENT OF THE DIGESTIVE SYSTEM IN HOMALEDRA SABALELLA CHAMBERS*†

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INTRODUCTION

The development of the digestive system of insects has been intensively studied by many investigators. Modern workers are apparently agreed upon certain fundamental structures and changes that appear to persist in certain groups. Corroboration of these points, however, has been shown in but relatively few orders. In view of the fact that no recent investigations upon the morphological changes that occur in Lepidoptera have been undertaken and with the purpose of studying certain points of anatomy and metamorphosis that have been recently demonstrated in certain other orders, the present study was undertaken.

HISTORICAL.

Among the first observers of metamorphosis in Lepidoptera were Malpighi (1669) and Swammerdam (1685), the latter using *Pieris brassicæ* and *Vanessa urticæ* for his observations. Réaumur (1734), Lyonet (1763), and Herold (1815) contributed observations on the external changes of larva to adult. It was not, however, until Weismann (1864) proved the presence of imaginal discs in Diptera and showed that parts of the larval body underwent disintegration or histolysis, that post-embryological studies began.

The morphological changes in the digestive canal have been more intensively studied in Diptera, Hymenoptera and Coleoptera than in Lepidoptera. The principal workers were: in Diptera, Weismann (1864), Ganin (1876), Kowalevsky (1887), Van Rees (1888), Hurst (1890), Miall and Hammond (1892), Vaney (1902), Pérez (1902, 1910), Thompson (1905), Hewitt (1907), and Snodgrass (1924); in Hymenoptera, Seurat (1869), Karawaiew (1897), Berlese (1901), Pérez (1911), and Tiegs (1922); in Coleoptera, Rengel (1896), Mobüsz (1897), Deegener (1900), Berlese (1900–1, 1913), Poyarkoff (1910), and Beal (1927).

Other orders that have been studied are Odonata, Needham (1897); Collembola, Folsom and Wells (1906); Neuroptera, Matheson (1912); and Thysanoptera, Müller (1927).

Anatomical studies on larvæ of Lepidoptera have been numerous since the famous treatise by Lyonet (1762). Bordas (1911) contributed the most recent and comparative study of the gross and histological structure of the digestive tract and malpighian tubes of some twenty-nine larvæ selected from the families Nymphulidæ, Sphingidæ, Arctiidæ, Cossidæ, Liparidæ, Saturnidæ, Cymalophoridæ, Notondontidæ, Noctuidæ, and Tortricidæ.

Post-embryological changes in the digestive tract of Lepidoptera are confined to the writings of Verson (1905) on *Bombyx mori* and Deegener (1908) on *Malacosma castrensis*. Cholodkovsky (1887) studied the histolysis and histogenesis of the muscle tissue in *Tinea* and Metalnikoff (1908) studied the phagocytic destruction of the muscles of the alimentary canal in the wax moth, *Galleria mellonella*. Samson (1908) working on *Heterogenea limacodes* Hufn. (Limacodidæ) and Hufnagel (1912) on *Hyponomenta padella* (Tineidæ) studied the metamorphosis of the Malpighian tubes. The latter investigations on the Malpighian tubes were continued by Ikeda (1913) and later by Ito (1920) working with *Bombyx mori* L. in Japan.

BIOLOGY AND LIFE HISTORY OF THE SPECIES.

The larvae of *Homaledra sabalella* Chambers (Order Lepidoptera, Family Cosmopterydidæ) live as skeletonizers on the leaves of certain palms and palmettos. The species is commonly known as the palm-leaf skeletonizer or palmetto-leaf miner. In the United States it is confined to the states of Georgia, Florida, Louisiana, and Texas. It is also reported from the following islands of the West Indies: Cuba, Porto Rico, Santo Domingo, and Haiti. The biology and life history of this form has been carefully studied by Creighton (1929).

Eggs are laid on the dried, twisted tips of the palm leaflets or on the "inter-leafing husk" at the base of the leaflet, (Creighton, 1929). On emerging the larvæ spin a silken web on the leaf and live beneath this. Frass from the leaf and excrement from the body are piled on top of this web. Six definite instars have been observed with the average length of time in each instar as follows: 1st, 12.66 days; 2nd, 8.43 days; 3rd, 8.59 days; 4th, 6.78 days; 5th, 5.72 days; and 6th, 11.54 days. During the last instar the larva spins a heavy silken cocoon next to the leaf surface. This is lined with a very fine layer of closely woven silk to which the cremaster of the pupa is attached.

The larvæ remains dormant for one to three days before pupation. The pupal period may vary from ten to twenty-two days depending upon humidity and temperature conditions. As the specimens for the present study were all reared under artificial conditions the environmental factors were fairly constant and the pupal period extended from a minimum of seventeen days to a maximum of twenty days. The adults mate readily in large test tubes or glass jars. They live normally from two to three days to ten to twelve days and do not feed at any time either in nature or under artificial conditions.

TECHNIQUE.

Mature larvae were collected from palm leaves and placed in individual petri dishes with a small portion of the palm frond.

The exact time of pupation was observed through the glass or by removal of the cover. Prepupae were also removed from the silk web of the cocoon and allowed to pupate in the open. As the normal cocoon is not completely closed at one end, it was easily unraveled from that point. Pupa were then transferred to small stender dishes and allowed to develop until the respective time for their fixation. Many duplicates were fixed for each period.

All specimens were killed and fixed in hot Bouin's solution (Picric acid, satuarated aqueous solution 75 c.c. formalin, 25 c.c; glacial acetic acid, 4 c.c.), Kingsbury and Johannsen, 1927:8). Certain of the late larval and early pupal stages were embedded in paraffin but the majority were double embedded in celloidin. Material remained in 4 and 8 percent celloidin over periods of not less than 2 weeks to a maximum of 2 months. As the pupa is heavily chitinized it was always necessary to prick or remove portions of the cuticle in order to insure infiltration.

All sections, both longitudinal and cross, were cut in serial order 7.5 microns in thickness. The majority were stained with Delafield's Haematoxylin and counter stained with a 2 percent alcoholic solution of Congo Red. Certain of the larvæ were stained with Iron Haematoxylin and counter stained with Congo Red.

In the late larval and prepupal periods specimens were fixed every hour. Pupa were selected in the act of pupation and at 2 hour intervals afterwards, up to the 30th hour. After 30 hours specimens were fixed just at eclosion and at intervals during their normal life period (10-12 days). The adults as well as the larvæ were selected from field collected material as well as from laboratory raised specimens. All the specimens used in the present study were collected, reared, and fixed at Gainesville, Florida, where the species occurs throughout the year.

The majority of the pupæ were selected during late fall to early spring, but some were reared in the summer.

DIGESTIVE SYSTEM OF THE MATURE LARVA.

Larva of *Homaledra sabalella* Chambers of the same age vary slightly in size under normal conditions. Creighton (1929) gives the mean or average length of 50 larvae immediately after eclosion as 1.53 mm. with a mean deviation of ±.1008 mm. In the present study only normal mature larvae in an active feeding state were used. Greater variation in size exists in this stage because of modifications in food and other factors that affect the larval period. The average mature larva measured 16.2 mm. in length from cephalic to caudal end. As the digestive system (Figs. 1 and 2) is a straight tubular structure extending between these points, the measurements,

accounting for slight variations in each individual, may be taken as follows: 1.1 mm. from the oral opening to the junction of the oesophagus and proventriculus, 1.3 mm. from the cephalic end of the preventriculus to the caudal end of the cardiac valve, 10 mm. from the cardiac valve to the pyloric valve, 1.8 mm. from the pyloric valve to the ileo-colic valve, 1.3 mm. as the length of the colon and .8 mm. the length of the rectum.

Fore Intestine.

Buccal Cavity. The buccal cavity or mouth is that area bordered anteriorly by the inner surfaces of the mouthparts in a typical mandibulate larva such as *Homaledra*, and extending caudad to the tubular pharynx. The cavity of the mouth measures 47 microns in length with a width varying from 34 microns at the median and widest point to 23 microns at the posterior end where it narrows perceptibly to become the pharynx.

The intima or innermost lining of the buccal cavity is a relatively thin chitinous layer lying over a narrow epithelial stratum in which a few scattered nuclei can be observed. The epithelial layer is thickest on the anterior, dorsal surface (9 microns) and narrows to a faint streak at the posterior end. The intima, however, is thinner anteriorly and widens posteriorly to form a lining of rather uniform width throughout the remaining region of the fore-intestine. The superior surface of the buccal intima is modified along its anterior two thirds to form delicate spines about 9 microns in length. These project backwards in the mouth. The lower surface of the cavity is smooth, but the upper is thrown into delicate wave-like folds along its entire length.

A band of longitudinal muscles, about 6 microns in width, lie exterior to a rather distinct basement membrane that surrounds the epithelial stratum. Several large circular muscles are situated just before the opening of the pharynx. A thin peritoneal membrane surrounds the muscular layer. Large dilator muscles are attached to the wall at the junction of the buccal and pharyngeal cavity.

Pharynx. The pharynx in most insects is not a definitely delimited area, but is commonly applied to a region between the mouth and oesophagus (Comstock, 1925:109). Haseman (1910:283) considers its caudal boundary in *Psychoda alternata* as marked by the posterior margin of the supra-oesophageal ganglion. The anterior margin of this ganglion marks the end of the pharynx in *Homaledra*.

The pharynx (Figs. 1 and 2) is slightly infundibular in shape, tapering from 15 microns at the buccal opening to 17 microns at the oesophageal aperture. The chitinous intima, continued from the buccal region, is slightly thickened through its anterior half and lies flat on an epithelial layer of flattened to ovoid cells, each with a definite oval nucleus. Bordas (1911:220) describes two zones in the chitinous intima of the anterior region of the pharynx in the larva of *Io Irene:* "une région interne, hyaline; transparente, compacte et non colorablé par les

reactifs, et une zone profonde a structure finement striée, et se continuant, presque sans ligne de démarcation, avec le cytoplasme sous-jacent." The present study appears to agree with this, but as the intima rarely exceeds 5 microns in thickness, the line of differentiation is not always clear. Continuous with this area, but lying caudad on the median lateral walls of the pharynx, the chitinous layer is thrown into ridges or rows, (9-12) which in longitudinal section appear to overlap posteriorly (Fig. 3). Heavy bristle-like projections from the intima line the overlapping margins and extend inwards. The superior surface is composed of rows of chitinous plates (19 microns long, 7 microns wide) with undulate margin bearing delicate hair-like bristles projecting caudad (Fig. 4). Verson (1905:534) describes the cuticula in the pharynx of *Bombyx mori* as especially thickened and armed with sharp teeth ("spitze Zähnen").

The epithelial layer of the pharynx consists of irregularly placed rather prominent oval to flattened cells, varying in diameter from 9 to 11 microns on the lateral and inferior surface to 13 to 15 microns on the superior with large circular nuclei (4 to 6 microns). The nuclear walls are distinct, as is also the cell wall in most preparations. The cells are scattered, some only connected by a faint strand of the epithelial tissue, other embedded in a deeper granular stratum. The basement membrane is clearly defined as it takes the stain more readily than the granular stratum which it surrounds, (Fig. 3, b. m.).

The anterior one third of the pharynx is surrounded by strong dilator muscles. Lying closely compressed to the basement membrane of the pharyngeal epithelium is a poorly developed layer of longitudinal muscle tissue, quite difficult to distinguish in many sections. The outer circular muscles are well developed and form a firm, almost continuous sheath about the entire tube, (Fig. 5, c. m.). In this stage (active larval) all the muscles show a normal striated condition. A peritoneal membrane surrounds the muscular layer and can be distinguished along the outer margin of the muscle bundles.

Oesophagus. The anterior portion of the oesophageal intima is smooth and flat. It begins at the cephalic margin of the supra-oesophageal ganglion and passes posteriorly over a deeply cleft and folded caudal region to the surface of the cardiac valve, and thence directly over the inner wall of the proventriculus. As the anterior region is directly caudad of the spines and chitinous plates of the pharyngeal wall, the oesophagus may be readily distinguished from the pharynx by the clefts and folds of its posterior wall, its thickened chitinous intima, its large and definitely outlined epithelial cells and the modifications in its muscular structure, (Fig. 6, oes.).

The epithelial cells in the anterior part are flattened, average 28 microns in length by 9 microns wide, with long oval nuclei 13 microns long. The cytoplasm is slightly granular to vacuolated with the chromatin in the nuclei staining as dark granules. The intima and epithelial layer are thrown into folds in the posterior region. In this region the epithelial cells gradually become larger, definitely cuboidal in shape, the largest measuring 38 microns long by 19 microns wide with

a circular nucleus 6 microns in diameter. The cells are densely vacuolated, the nucleus granular, and a rather large nucleolus is visible. A very definite sheath of longitudinal muscle tissue lies next to the basement membrane with a prominent continuous layer of circular muscles exterior to it. The peritoneal membrane can be distinguished at points along the course. The lumen, which has narrowed slightly between the oesophageal folds, widens beyond them to form the cavity of the proventriculus or crop, (Fig. 6, prov.).

Proventriculus. The proventriculus in the mature larva of *Homaledra* is formed by a widening of the posterior region of the oesophagus and a reduction in the normal structure of the wall to form a thin walled sack or reservoir. The contents of this chamber in a normal feeding larva appears to be in practically the same physical condition as in the fore part of the ventriculus.

Many investigators have studied the proventriculus or fore-stomach in other insect forms. It is also known in the literature as the "masticating stomach," and "Kaumagen" of the German workers. In Lepisma it is a spherical gizzard provided with six teeth; in the Gryllidæ there are six folds that form a valve between the crop and proventriculus. It is especially well developed in many carnivorous and wood boring Coleoptera, where it is muscular, lined within with chitin and usually provided with teeth, brushes or plate-like structures or folds. Beal (1927) describes such a complicated thickening of processes in *Petyogenes* as originating from secretions of the epithelial cells. The proventriculus is also found in certain Mecoptera, Odonata, Isoptera, and Hymenoptera, (Imms, 1925:98, 99). In the honey bee it is a narrow valvular region between the honey sac and ventriculus (Snodgrass, 1925:156-158); in the Diptera it is also reduced to a valve.

The proventriculus in *Homaledra* offers no special structure of importance, (Fig. 5, prov.). The walls are thin and the chitinous intima slightly less in thickness than over the oesophagus proper, (Fig. 7). The epithelial layer is very narrow and often quite indistinct with an occasional flattened and elongated nucleus with dense chromatic granules. The basement membrane stains distinctly. Longitudinal muscles form a narrow outer sheath and are strengthened by circular muscles at regular intervals. Both lie within the peritoneum, which like the basement membrane stains clearly, and is quite visible in places.

The wall of the proventriculus extends posteriorly for 1.2 mm. and then forms a narrow fold extending anteriorly (.4 mm.) in the lumen to form the cardiac or oesophageal valve (Fig. 6, card. v.). Bordas (1911) found a similar valve in all the larvæ of Lepidoptera that he examined: *Cnethocampa, Carpocapsa, Pleretes, Vanessa, Sphinx, Spilosoma, Pygaera, Cossus, Stauropus, Ascherontia* and others. Verson (1905:534, 535) described a cardiac valve in *Bombyx mori.* Other writers have shown its existence in several species of Diptera, Hymenoptera, Coleoptera, Orthoptera, Neuroptera, and Thysanura (Lepisma).

At the junction of the cardiac valve with the wall of the ventriculus a triangular muscular area is formed with several annular muscles in

the center, (Fig. 8). A sheath of thin muscle fibers with an outer peritoneal covering extends over this area and continues over the wall of the ventriculus. No definite muscle fibers can be detected between the thin lamellæ of intima and flatly compressed multinucleated epithelial layer that compose the cardiac valve, except in the fold of the distal border, which is slightly enlarged. At least 3 to 4 annular muscles are found here. Numerous small flattened nuclei with very small chromatic granules line both walls of the epithelial stratum, (Fig. 6). These cells will later form the histoblastic cells of the oesophageal ring. There is no indication of any of the blood sinuses as reported by Imms (1907:301) in Dipterous larvæ.

Mid-Intestine.

The ventriculus or stomach is a straight tubular organ from 9 to 10.5 mm. in length, and under normal conditions of feeding shows a diameter of 1 to 1.5 mm. As the stage of feeding and digestion determines the exact shape, normal modifications will occur at all times, (Figs. 1 and 2).

Peritrophic Membrane. A conspicuous peritrophic membrane begins at the basal region of the cardiac valve and forms a membranous tube within the ventricular wall, (Fig. 6, p. m.). It is somewhat separated from the epithelial cells and surrounds partly digested and undigested food materials. The cell nuclei near the base of the cardiac valve are densely chromatic and the cytoplasm somewhat glandular in character. Some sections show definite glandular cells along the caudal border of the valve with granular chromatic nuclei and fibrous vacuolated cytoplasm. Probably the peritrophic membrane is secreted continuously from these cells as it is the only point where attachment is made. This conforms with the findings of Bordas (1911:229-232) in the larva of *Io Irene* and other Lepidoptera larvæ as well as with the works of certain other writers. Among those that believe the origin to be from specialized glandular or germinal cells near the anterior end of the mid-intestine are: Van Gehuchten in *Ptychoptera contaminata* (1890), Balbiani in *Chironomus* (1890), Miall and Hammond in *Chironomus* (1900), Hasemann in *Psychoda* (1910), and others.

Another type of peritrophic membrane has been described for *Aeschna* by Voinov (1898) and by Trappmann (1923) and by Snodgrass (1925) in the honey bee. In this the membrane is formed by a delimination of the inner or free margin of the cells lining the mid-intestine (Imms, 1925:101). It is a non-chitinous structure quite different from that found in Lepidopterous larvæ.

Ventriculus. The wall of the mid-intestine or ventriculus consists principally of a broad band of tall columnar epithelial cells resting on a basement membrane or tunica propria. The muscle layer is thin but complete, (Fig. 9). Lying next to the basement membrane are the closely set fibers of circular muscles with an outer sheath of thin longitudinal muscles containing many nuclei. The nuclei occur regularly along the length of the tube.

The enteric epithelial cells are somewhat compressed but show considerable regularity. Cells in the anterior third measure 58.3 microns in height with a widest diameter of 11.3 microns; cells in the median area measure 67.7 microns in height with a diameter of 18.8 microns and those in the posterior third measure 48.9 microns in height and 9.4 microns in diameter. Normally the cells are narrower at the base and expanded in the median or distal region, (Figs. 6, 10, 11, 12). The nuclei are oval to circular in shape and vary in length from 5.6 microns to 11.3 microns with a diameter from 3.8 microns to 5.6 microns. They lie in the lower third to median region of the cell and contain fine chromatic granules and a nucleus which stains distinctly in the preparations. The epithelial cells of the anterior region of the mid-gut possess vacuoles within a rather reticulate, coarsely granular cytoplasm, (Fig. 10). The cells of the median (Fig. 11) and posterior region (Fig. 12) are more densely granular or finely vacuolate. The cytoplasm of the cells in the extreme posterior area contain an abundance of chromatic granules and stain deeper than those in the foreward portions. Van Gehuchten (1890) in Dipterous larva showed secreting or glandular cells in the anterior part of the stomach and absorbent cells in the middle and posterior portion. Oertel (1928) described anterior and posterior chromatic cells in the mid-intestine of the honey bee. In *Homaledra* secretion is probably more abundant from the anterior half of the ventricular epithelium, but may be found at intervals along the entire stratum.

At the base of the epithelial cells are small oval to pyramidal shaped cells resting flatly on the basement membrane, with dark circular nuclei, (Figs. 10 and 11, hist. c.). In the anterior and median region these cells are usually single and very small, but placed at close intervals along the basement membrane. In the posterior region of the epithelium of a mature larva, these cells are arranged in small groups, (Fig. 12, hist. c.). Such cells are more commonly known as replacement cells, but have been described as epithelial buds, cells nests, Kryptes, Drüsenkrypten, Drüsen, nidi, etc. They have been found in many other insects: in *Tenebreo* (Coleoptera) by Frenzel (1885), in the Cockroach by Miall and Denny (1886), in *Crytops* by Balbiani (1890), in the Odonata by Needham (1897), in *Nasonia* (Hymenoptera) by Tiegs (1922), in the California Locust by Tietz (1923) and others.

The inner or free surface of the epithelial stratum is marked by a distinct striated hem (Imms, 1925:100) or border varying from 3.8 microns to 9 microns in width (Fig. 12, s. b.). Lying between this and the peritrophic membrane is a finely granular substance, supposedly secreted from the underlying epithelial cells. This is more abundant in the posterior third of the ventriculus especially in the region of the pyloric valve.

Hind-Intestine.

The beginning of the hind-intestine (Figs. 1 and 2, malp. t.) is generally marked in insects by the insertion of the Malpighian tubes, (Imms, 1925:102). This region is readily distinguished in *Homaledra*,

externally, by means of a shallow groove or furrow and internally by a well developed pyloric valve bearing certain densely chromatic, typical histo-blastic cells. The entire tube is divided into three rather well marked regions: the ileum or small intestine, which consists of an anterior and posterior portion: the colon, or large intestine: and the rectum. In an average mature larva the dissected ileum measures 1.8 mm. in length, the colon when not distended 1.3 mm. and the rectum .8 mm., width varying from 1 to .8 mm. The muscular coat of the ileum separates it distinctly from the other regions. Verson (1905:553–556) describes three somewhat similar divisions in the larva of *Bombyx mori*. Bordas (1911:244–247) shows two enlargements in the posterior intestine of the larva of *Io Irene*, *Phalera bucephala*, and *Cnetocampa processionea* (Lepidoptera), but does not differentiate the regions.

The mid-intestinal epithelium ends abruptly, but a narrow wall continues and forms a fold which tends to decrease the diameter of the lumen (Fig. 13, py. v.). Immediately beyond this fold, or valve, the tissue expands to form a smooth walled tube, the ileum. The anterior surface of the fold which constitutes the pyloric valve, possesses a very flat, highly chromatic, multi-nuclear layer of epithelium. This continues to the margin of the valve, where it joins a group of larger but similar densely stained cells on the posterior side of the apex (Fig. 14, hist. c.). Adjacent to these cells are others more elongate, highly vacuolate with granular, oval nuclei. The first are definite histoblastic cells, whereas, the latter are glandular in character. Together they constitute the anterior or frontal wall of the ileum (Fig. 13, il.).

Extending from the outer edge of the pyloric valve is a definite peritrophic membrane, which continues through the lumen of the ileum. Whether this chitinous structure is a continuation of that from the mid-intestine or a production of the cells at the point of its apparent attachment at the pyloric valve cannot be definitely ascertained. However, when the digestive tract is fully distended with food, the pyloric valve is flattened out (Fig. 15, py. v.) and the lumen of the anterior iliac chamber is continuous with that of the mid-intestine. The cells of both the anterior and posterior histoblastic rings are very similar in character.

Two urinary ducts carry the contents of the Malpighian tubes (Figs. 1 and 2, ur. d.) into the anterior chamber of the ileum. Each opens by a single pore on the lateral walls of the tube just below the pyloric valve.

The epithelial cells lining the thin walled anterior region of the ileum are very flat and their walls very indistinct, but the nuclei are prominent, oval, and contain fine chromatin granules which stain readily. The inner surface is covered with a very thin flat chitinous intima that continues in much the same manner over both the anterior and posterior regions of the ileum. The muscular wall of the anterior chamber is thin and not as well developed as that of the posterior. A few ental circular muscle fibers lie against the basement membrane and a strong band of longitudinal muscle encloses them. The ectal

circular muscles are not well developed, but the peritoneal membrane stains readily.

In the middle region of the ileum is a complicated fold, the ileal valve (Hasemann, 1910) which separates the anterior from the posterior chamber (Fig. 13, il. v.). The epithelial cells lining this valve are large and cuboidal in shape with curved walls, most of which are quite distinct. The nucleus is densely granular, the nucleolus prominent and the cytoplasm clear, reticulate in the outer half of the cells, but granular to finely vacuolate in the basal region (Fig. 16). In the depressions produced by the folded epithelial stratum, are well developed ental circular muscles, about 17 in number. Between and enclosing these muscles are longitudinal strands of muscle tissue, some of which make their insertion on the basement membrane of the larger epithelial cells. Beginning at the anterior border of the valve are at least 17-18 very large ectal circular muscles (Fig. 16, ec. c. m.) which extend slightly beyond the folds of the valve. The peritoneal membrane, continuous from the anterior region, shows distinctly, (Fig. 16, per. m.). It proceeds posteriorly over these muscles and continues over the smaller circular muscles of the posterior portion.

Posterior to the ileal fold (Fig. 13, il. v.), the epithelial cells are low, cuboidal in shape with rather indistinct cell walls. They measure between 33.8 and 37.6 microns in length and have a uniform depth of 16.9 microns. The nuclei are oval to elongate (3.8 microns by 28.2 microns) and highly chromatic. In the median and posterior region the cells are larger, some remaining cuboidal (67.6 microns by 41.4 microns; nuclear diameter 18.8 microns), other definitely irregular to polyhedral in shape (Figs. 19, 20, 21, 22). The larger cells measure 78.9 microns by 26.3 microns and possess large nuclei with coarse granular to fibrous-like chromatin. The cytoplasm of the entire epithelial layer of this region is finely granular to minutely vacuolate and contains many darker staining granules of chromatin. No normal pigmentation was observed in this region of *Homaledra*. The basement membrane is distinguishable in the fore part but weak and difficult to determine in the posterior region because of the thinness of its structure and the irregularity of the overlying cells. It can be observed in some sections over the open spaces between the cells. The chitinous intima is not especially thickened over the folds of the ileal valve or over the low cuboidal cells. Beyond the latter, however, it begins to thicken and form a heavy lining to the posterior walls of the chamber (Figs. 21 and 22, chi. i.) and then continues caudad to cover the wall of the colon.

The circular muscles are very distinct from the ileal valve back to the colon (Figs. 13 and 22, c.m.). They are at first small and oval but gradually become larger and are block-like to irregular (in cross section) in the posterior region. The smaller bundles measure 13.1 to 16.9 microns in diameter, the larger ones average about 56 microns in diameter. In longitudinal sections 52 of these circular muscles were counted. The peritoneal membrane is very distinct along the course of the smaller bundles, but barely distinguishable bordering the larger

muscles. Longitudinal muscles are weakly developed, several strands are visible in the region of the colon and just posterior to the ileal valve, (Fig. 22, 1 m.).

Several prominent clefts appear in the epithelial stratum of the ileum just before entering the colon, but no definite valvular structure is to be found in the larva. In many cases the epithelial wall is thrown into distinct folds, (Figs. 20 and 21). The lumen is considerably narrower here than in the forward region; the epithelial cells are polyhedral to oval in shape and large; the chitinous intima thickened and the circular muscles very strong. The narrow lumen of the ileum opens abruptly into the very much expanded cavity of the colon, (Fig. 22, col.).

Colon. The colon is normally short, about one-half the length of the ileum, (Figs. 1 and 2, col.). The width is very variable but is usually at least twice that of the small intestine. The chitinous intima is thinner than in the ileum and is thrown into numerous short folds in the partially filled organ, (Fig. 22, chi. i.). The epithelial layer consists of flattened, irregular to oval cells with prominent nuclei, but often indistinct cell walls, (Fig. 23). They are closely compressed by well developed circular muscles that press against the basement membrane. Longitudinal muscles are weakly developed but may be observed in delicate strands. Outer circular muscles surrounded by a peritoneal membrane complete the very substantial wall to this region, (Figs. 22 and 23). During the normal feeding of the larva this sac is greatly distended with waste food and debris.

Rectum. The posterior region of the hind-intestine is a narrow, short continuation of the digestive tract from the colon to the exterior. Commonly called the rectum or "Mastdarm" of the German workers, the tube in the larva of *Homaledra* can hardly be compared with the structure in grasshoppers, cockroaches, certain beetles and Odonata. In the various Lepidopterous larvæ studied by Bordas (1911) no differentiation of this region is reported.

The anterior region of the rectum is marked by several strong sphincter muscles (Fig. 22, sph. m.) inserted on the strong chitinous intima between the rather flat, oval epithelial cells. Their attachment is on the adjacent body wall.

The tube of the rectum is slightly bent and varies in diameter from 18.8 to 24.3 microns. The chitinous intima is thick, and is modified in the median and posterior half to form backward projecting bristles (11 to 13 microns in length), (Fig. 22, b.). At the anal opening it is continuous with the external chitinous covering of the body. The epithelial cells pass inconspicuously into the layer of epidermal cells lining the integument. The muscular layer is poorly developed and can be distinguished only over the fore and median region of the tube.

SALIVARY GLANDS OF THE MATURE LARVA.

Spinning Glands.—In Lepidopterous larvae the labial or salivary glands are modified to form silk producing organs. These are usually tubular in character and "unite to form a single duct opening into the upper lip at the end of the ligula, which is modified to form the spinneret," (Packard, 1898: 339). Measurements from a number of Eurasian caterpillars (Helm, 1876) show the length of the glands in certain species as slightly less than the length of the body, in others slightly longer, and in some such as *Telea polyhemus* as much as seven times the body length. The typical structure and function of the spinning glands has been thoroughly reviewed by Imms (1924: 140–141) and Schroder (1912: 285–300).

The spinning or silk glands of *Homaledra* consist of two white, tubular structures about 13 mm. in length when extended. The anterior region, or salivary duct, is narrow and tubular, the posterior, or glandular portion, is thickened, tubular and bent in one or two loops, (Figs. 24 and 25). The union of the duct with the glandular area is visible externally in the dissected specimen as well as in histological sections. The ducts from the respective glands unite just before the external opening in the anterior median floor of the buccal cavity, (Fig. 26).

Functional Salivary Glands. The mandibular muscles in the head of the larva of *Homaledra* are well developed and fan-shaped. On the lower inner face of each is the mandibular gland, a tubular structure, which extends almost to the posterior border of the head, (Fig. 27). The anterior part is a thin walled duct; the posterior is secretory and consists of typical gland-like cells around a narrow lumen, (Fig. 28). Similar glands have been described from other Lepidopterous larvæ (Imms, 1924:139). They are well developed in *Cossus cossus* L. (Henseval, 1897) and are short and sac-like in the larva of *Papilio alexanor* Esp. (Bordas, 1904). They have also been described from *Stauropus fagi* L. (Schroder, 1912), from *Mantis religiosa* L. (Bordas, 1907), from *Apis mellifica*, (Snodgrass, 1925) and from other insects.

Maxillary glands are also present in the larva of *Homaledra*. They are compound tubular structures that lie closely compressed in depressions on either side of the floor of the buccal cavity, (Fig. 26, max. gl.). They are situated below the mandibular glands and laterad of the spinning glands. In some specimens they appear to extend posteriorly along the lower lateral wall to near the region of the thorax. Although different in shape, the glandular structure of the cells resembles that described by McDunnough (1909) in the larva of *Chrysopa perla* L. Owing to their compressed position the exact number of tubular units could not be determined. The duct is very narrow but was observed

in many sections. The glands appear to be similar in character to those described and pictured by Henseval (1895) in the head of *Limnophilus flavicornis* Fabr.

MALPIGHIAN TUBES OF MATURE LARVA.

Similar to most Lepidopterous larvae there are six Malpighian tubes in *Homaledra*, (Figs. 1 and 2, malp. t.). Each three empty into a separate, narrow urinary duct that opens by a single pore into the lateral wall of the ileum, just below the pyloric valve. The urinary duct gives off two tubes, one proceeding posteriorly, the other anteriorly. The latter branches at once to form a long anterior tube that extends laterally along the digestive tract to about the median region of the mid-intestine, where it divides. One branch then loops around the mid-gut, but returns to proceed posteriorly with the other over the same surface. The anterior branch of the opposite side divides in a similar manner and its two ends come to lie on the opposite face of the mid-intestine. The two posterior tubes do not branch, but end free from the wall of the intestine in the anterior region of the rectum. The tubes are yellowish white in color, somewhat convoluted and have smooth walls.

Many variations have been found in the urinary tubes of Lepidopterous larvæ. Cholodkowsky (1887) found four tubes in *Galleria mellonella;* Bordas (1911) reported great variations in appearance but in all forms examined six tubes were observed, in two groups of threes, with the exception of *Carpocapsa pomonella* Fr. in which there were only four. In general the number of malpighian tubes in insects is said to be very constant within the limits of most of the orders (Imms, 1925:130-132). The number, however, varies from 2 in Coccidæ to more than 120 in certain Orthoptera.

POST-EMBRYOLOGICAL DEVELOPMENT.

After the active mature larva of *Homaledra* ceases to feed, it defecates and molts and then passes into the sixth or last instar. This usually occurs within the silken cocoon. Then the prepupal or resting period begins, during which the larva is fairly active at first, but gradually settles down, contracts, straightens its body, becomes pale in color, loses the activity of its legs and responds only slightly to touch. The duration of this instar is variable, but it is usually completed in two to

three days. In some cases it may be as short as one day, or in others it may be prolonged to four or five days. Histological changes in this species are normally slow as compared with numerous Dipterous forms that have been studied by others.

Shortly before the larva becomes immovable as a prepupa, that is, between eight to ten hours before pupation, the histoblastic or imaginal discs of the integument begin to proliferate and increase in size. These are groups of histoblastic cells that occur at intervals among the larval integumentary cells, (Fig. 29, hist. d.). They are normally small, short, and columnar and packed closely together. The cell wall is indistinguishable and the nucleus elongate, highly chromatic, staining more deeply than that of the adjacent cells. These cells begin to increase rapidly and push against the larval epidermis.

During the following three to four hours the larva becomes gradually immovable and the body is contracted. The integumentary histoblastic discs rapidly extend over the integument, (Figs. 30 and 31, i. hist. d.). The larval cells are slightly distended; the nucleus is prominent and the nucleolus large. They become vacuolated and the nucleus breaks up into small parts which on the disintegration of the cell membrane float out into the body cavity, (Figs. 30 and 31, d. l. c.). These elements have been termed "pseudonucleated globules" by Tiegs (1922) in *Nasonia* (Hymenoptera). This change can be observed along the entire course of the integument and seems to be entirely a chemical process. A few leucocytes are present in the blood and appear to digest some of the broken down cell material after it is liberated. They are not found near or in any manner attacking the normal cells.

On the disintegration of the larval cells the histoblastic cells crowd into their place and gradually assume a normal columnar appearance, (Fig. 31). A delicate outer layer of chitin is secreted and at the same time large moulting glands, arranged irregularly along the body wall, pour their contents into the area between the old body wall and the thin new layer of chitin. Although the histoblastic discs have united along the outer integument and chitin is deposited on the outer edge, the process of complete replacement is not accomplished until one or two hours after pupation. In a pupa two hours old, the chitin has thickened and in four to six hours it is very hard and pigmented. Specimens over 72 and 96 hours old offered

considerable difficulty in preparation because of their dense sclerotization. It was always necessary to remove part of the chitin in order to secure proper infiltration.

Fore-Intestine.

About the time that the integumentary histoblastic discs begin their activity, changes begin in the oesophagus. The thickened chitinous intima becomes detached from the proventriculus and oesophageal wall in the posterior region just anterior to the cardiac valve. It gradually becomes loosened and lies in twisted rolls in the lumen of the fore-intestine. Within five to six hours before pupation the pupal body shrinks (Fig. 29) within the old larval skin, and, as the chitinous lining is continuous with that of the outer wall, the former is pulled forward into the median region of the oesophagus. Meanwhile histoblastic discs are growing and replacing the larval cells that border the former buccal cavity, which is gradually obliterated as the pupal wall shrinks from the larval cuticle. When feeding ceased the proventriculus became constricted and the pyloric valve more flattened than in the normal feeding larva. Coincident with the histoblastic activity in the anterior region of the fore-gut, the histoblastic cells of the cardiac valve increase rapidly and begin to push their way in a flat compressed line anteriorly against the larval cells of the oesophagus, (Fig. 32, hist. d.). A group from the posterior margin of these cells begin to extend out into the anterior ventricular lumen. Just before pupation these latter cells form a delicate tissue-plug across the anterior end of the ventriculus, (Figs. 32 and 33, t.p.).

The fore-intestine in the larva is a straight tube, but about three to six hours before pupation, the superior frontal line of newly forming integumentary cells bends ventrally and along with the inferior frontal line bends below the former axis of the larval fore-gut. At pupation the new oesophageal opening lies diagonally below and somewhat posterior to the former buccal opening, (Fig. 34). The lumen is at that time very narrow and bordered at its exterior end by clusters of close pressing integumentary histoblastic cells, (Fig. 34, i. hist. c.). At pupation the larval muscles of the pharyngeal and oesophageal wall are quite distinct in outline. They appear clear to granular with the larval nucleus irregular and coarsely granular in the center. Striations are evident in some but rather indistinct, others have completely lost them.

In the six hour pupa the muscles in the anterior and median region of the fore-gut show further signs of disintegration. The nucleus is finely granular and scattered; the whole structure is faint in color. Numerous vacuoles are present and the muscle tissue is contracted and irregular. Owing to the small size of these muscles, the striations are difficult to see. In some of the larger head and body muscles which are undergoing similar changes at the same time, the longitudinal fibrillæ appear to persist throughout the whole process, but the striations disappear completely in some.

In the six hour pupa the histoblastic cells from the integument have progressed mid-way to the anterior angle of the oesophagus and by the 11th hour they have reached the apex. The anterior muscles have completely disintegrated at this time and some of their remains can be detected in the blood along the path of the fore-gut. A few very flat to slightly triangular-like dark staining myloblast cells can be seen in the near region of the cardiac valve where the disintegration of the larval muscles appear to be a little more rapid. By the 11th hour the histoblastic cells from the cardiac valve, which began to increase at the same time as the integumentary histoblastic cells, have slowly grown anteriorly to a point about mid-way from the cardiac valve to the apex of the bent oesophagus. The larval cells become enlarged and the contents appear granular with numerous vacuoles in the cytoplasm and in the nucleoplasm. The nucleus breaks up into bits; the wall disintegrates and the contents pass off into the body cavity. The process is almost identical with the degeneration and disintegration of the larval integumentary cells. The new cells lie flat with elongated nuclei parallel to the lumen of the oesophagus. Even before the larval cells are completely disintegrated the histoblastic cells have formed a thin sheet, lining the lumen.

The two sheets of growing cells, the anterior originating from the integumentary histoblastic discs, the posterior from the histoblastic cells of the region of the cardiac valve, finally meet and fuse in the 32 hour pupa. The larval epithelial cells are still disintegrating and only the larval muscles in the region of the apex of the oesophagus persist in their original outline. A thin line of myloblasts line the posterior region of the oesophagus and a few scattered ones appear near the anterior portion. At the 30th hour a thin line of chitin is being secreted along the anterior wall of the lumen.

By the 40th hour after pupation the larval muscles surrounding the apex of the new oesophagus have completely broken down and the thin myloblasts occupy their place. In the 48th hour pupa the myloblasts have increased in size and are connected by thin strands. In the 72nd hour pupa the oesophageal epithelial cells have assumed their final character in all but the posterior region. They form a narrow syncytium-like layer with flattened elongated nuclei scattered irregularly along the wall. A thin layer of chitin forms a continuous inner lining to the entire passage. The muscular wall though thin and weakly developed is complete at this period, (Fig. 35).

Leucocytes are rare in the median and anterior region of the oesophagus but more abundant near the cardiac valve. They appear near the disintegrating muscles and often close to the histolyzing epithelial cells, but do not attack them until the latter have broken out into the blood space. The various processes that result in the dissolution of the larval cells of the pharynx and oesophagus, as well as the destruction of the associated muscles are apparently due to chemical reactions that occur within the tissues themselves or in the blood of the insect during this period. There is no evidence to show any indication of phagocytosis.

Oesophageal Diverticulum. In the 60 hour pupa, a small pouch or diverticulum begins to appear in the wall of the oesophagus just anterior to the closely packed layer of histoblastic cells forming at the cardiac valve, (Fig. 36, oes. div.). The myloblasts follow the outgrowth of histoblastic cells that compose this structure (Fig. 37, hist. c.) and lie in a loose line about the periphery, (Fig. 37, my.). The position of the diverticulum at first is at right angles to the axis of the oesophagus, but by the 96th hour its epithelial cells have formed a thin walled pouch that lies along the side of the anterior end of the ventriculus, (Fig. 38, oes. div.). The length at this age is .6 mm. (600 microns), the greatest width in the median region, .075 mm. (75 microns), and the thickness of the wall uniformly 7.5 microns. The myloblasts have united and form a thin barely distinguishable muscular sheath about the diverticulum.

In the pupa of 120 hours the oesophageal diverticulum has increased in length to 1.1 mm. and the walls are partially collapsed, (Fig. 39, oes. div.). The histological structure shows a thin multi-nucleated syncytium with a delicate line of muscle tissue about it, (Fig. 40, oes. div.). The lumen contains a finely granular substance, which may either disappear later or remain in the pouch.

The diverticulum reaches its greatest length (1.4 mm.) in the 168th hour pupa and at this stage its growth is practically complete, (Fig. 41, oes. div.). The cavity may be collapsed or distended at this time. In the majority of cases where it is distended the lumen is mostly empty. No further change is noticeable until the 384th hour when the epithelial cells lining the cavity begin to round out and a definite membrane of chitinous material forms an inner tubular lining to the pouch, (Fig. 42, chi. l.). This lies free from the cells of the wall of the diverticulum, but is attached to the histoblastic cells at the point of the opening into the oesophagus.

By the time the cardiac valve opens, the histoblastic cells in that region have multiplied and formed a thickened multinuclear deep staining structure that forms a sort of collar between the cavity of the ventriculus and the oesophagus. The oesophageal diverticulum enters the oesophagus at the anterior border of this thickened wall, (Fig. 42). In the imago this pouch is non-functional. Dissections show many modifications in its shape and size, (Figs. 43, 44, 45, 46). Usually it is greatly contracted but when expanded it is mostly full of air, (Fig. 45, oes. div.).

Mid-Intestine.

All the undigested and coarse granular food material present in the last feeding stage has been removed from the ventriculus by the time the histoblastic cells in the region of the cardiac valve begin to proliferate. By the time of pupation a tissue plug is completed in this region and forms a complete membrane over the lumen, closing the ventriculus anteriorly. It has thin points of attachment with the remaining cells of the histoblastic ring. The median part of the plug is enlarged and consists of closely pressed irregular to polyhedral shaped cells with small dark staining nuclei, (Fig. 33, t. p.).

The histoblastic cells in the region of the pyloric valve also begin to increase at the same time as do those in the region of the cardiac valve. Their action is similar to those in the forward region and a tissue plug is also formed in this region, but is not complete until six hours after the pupa has formed, (Fig. 47, t. p.). During this interval, however, the products of the ventriculus do not enter the posterior intestine. This is probably due to the inactivity of the muscular wall, the viscid nature of the cellular secretions and the consolidations of the contents to form a bulky "yellow body."

As the anterior and posterior histoblastic areas begin to increase, there are very definite changes in the structure and contents of the ventriculus. With the absence of food in the lumen the epithelial cells begin at once to secrete a finely granular substance. This is viscid in nature and fills the entire cavity. The distal portion of the cells become swollen and contain many chromatin granules and vacuoles. The median and basal regions of the cells are coarsely vacuolate to reticulate and apparently empty except for the nucleus which remains in the contracted, narrow basal region. At first, only a clear homogeneous secretion is thrown off, but this is followed by larger globules which contain most of the chromatic material of the cells. The first secretion has been termed the "yellow body" by Mansour (1927) in *Calandra oryzæ* Linn. Pérez (1910) applies a similar use of the term in *Calliphora erythocephala* Meigen but pictures a somewhat later stage. Although this may be considered the beginning of the formation of the yellow body, it is not completed in *Homaledra* until pupation.

In many cases all but the basal part of the cell is ejected. The contents of the cavity offers a very complex appearance. The center is clear to coarsely granular and the circumference is densely packed with the globules of cell contents. At this time the entire ventricular wall begins to contract and numerous folds occur along its entire structure. This action is accompanied by a gradual loosening or dissolution of the base of the cells from the basement membrane, (Fig. 48). The latter containing the larval nuclei move into the lumen and press against the already compact contents. This process occurs at the same time along the entire ventricular wall and is probably the result of chemical action. It is doubtful if any muscular activity is available to accomplish this as the slight folding of the wall could not produce such an effect.

At the beginning of this process the replacement cells (Fig. 48, r. c.) at the base of the epithelial cells appear as in the larvæ. Succeeding intervals show them slightly enlarged and much more numerous. The factors that bring about the degeneration of the epithelial cells do not affect the replacement cells in any visible manner. Immediately after the larval cells are sloughed off, the replacement cells multiply and cover the basement membrane lining the ventricular cavity. They expand and become typical low cuboidal to low columnar cells not over 23 microns in height, (Fig. 33, v. epith. c.). Pupation finds the epithelial walls lined with these cells; the central body-contracted into a somewhat lobulated structure with a lighter, granular median region surrounded by semi-fibrous strands, densely lined with degenerating

larval nuclei, (Fig. 49). Lying next this compact mass or "yellow body" (Fig. 49, y. b.) is a finely granular and reticulate substance that separates it from the newly formed epithelial cells, (Fig. 49, s.e.c.). Pérez describes the completed "yellow body" in *Calliphora* as a sort of cystic body, divided into chambers which are surrounded by very small flattened nuclei, quite different from the larger oval nuclei that line the inner divisions. No distinguishable difference can be observed in the scattered nuclei in the "yellow body" of *Homaledra*.

The "yellow body" was originally observed by Dufour (1846) and later interpreted as the remains of the proventriculus by Weismann (1864). It was first observed to be an agglomerated mass of exuviated epithelial cells by Ganin (1876). Lowne (1890-1895), Van Rees (1888), Kowalevsky (1887), and Pérez (1910) have described the structure. Pérez (1910) believed that certain digestive ferments are secreted from this mass of degenerating cell tissue. A similar function is attributed to the "accumalation of granular debris" in the mid-intestine of *Nasonia* by Tiegs (1922). The latter worker especially emphasizes the importance of this mass, which is gradually reduced in size during the pupal growth, as a probable source of nutritution to the forming imago. Observations indicate similar function in *Homaledra*.

Six hours after pupation the "yellow body" has contracted to about one third the diameter of the ventricular lumen and is beginning to show some signs of chemical disintegration. The nuclei are reduced and scattered irregularly through a densely granular but homogenous mass. By 11 to 12 hours after pupation, the central mass may be found broken into two or three parts. It is then greatly reduced and surrounded by a finely granular, dense, spongioplasm-like substance that fills the lumen.

After the liberation of the larval epithelial cells, the ventricular wall resumes its smooth outline. In the six hour pupa the ventriculus is an elongated oval body with narrow conical neck and funnel-like base. The epithelial cells in the basal region have begun to proliferate in the fifth to sixth hour and by the eleventh hour they have formed an irregular mass of cells (Fig. 47, m. v. e. c.) that close over the tissue plug, produced in the region of the pyloric valve. The cell walls in this mass are compressed, but distinct. The cytoplasm is clear to vacuolate and the nuclei are irregularly placed. This mass of epithelial cells may completely fill the funnel-like lumen at the end of twenty-four hours. Further increase is prevented by changes within the epithelial cells themselves.

In the twenty-four hour pupa the epithelial cells of the ventriculus have begun to increase slightly in size. The free ends enlarge and the cells become elongate and pear shaped, (Fig. 50.). By thirty-six hours the cells have increased in height from 16 to 18 microns to 28 microns in the anterior and median region and from 28 to 90 microns in the posterior portion. Small vacuoles form in the twenty-four hour stage and the cells soon appear as if full of small droplets which adhere together. This forms a dark staining mass that forces its way out at the surface. New masses appear to follow and in the elongated cells

of the thirty-six hour stage several of these masses occur in the cell at the same time, (Fig. 51). With the enlargement of the distal end of the cell, the basal part becomes narrow and numerous replacement cells may be seen between the bases of the epithelial cells. Disgorged cells seem to retain the nuclei in most cases, although some of the cells seem to be loosened at the base. Relatively few nuclei can be found among the cellular secretions. Many of the epithelial cells are replaced by the replacement cells at their base. This process can be observed in all stages of development. The new mass of finely granular, vacuolated substance along with many of the cells completely fills the lumen and surrounds the "yellow body," now reduced in size and stained considerably darker. This period of excessive cellular secretion precedes the presence of vast numbers of leucocytes through the body cavity. The duration of this condition varies somewhat. In the average pupa of forty hours the process is almost complete but in some cases it may continue as late as the 72nd hour. Usually, however, the secretory process is completed by the 48th hour pupa and the epithelial layer has returned to its former, low, characteristic cuboidal cells.

During the interval from the 48th to the 120th hour there are no further changes in the cell structure, and their growth is slight, still remaining cuboidal in shape. Between the 96th and 100th hour there is a slight renewal of the former secretory process, but it does not appear to cause any excessive destruction or renewal of cell tissue. By the 152nd hour (6⅓ days) the cells are cuboidal again, tending to low columnar at forward and posterior ends. The nucleus is small, circular, and in the basal or median region of the cell. The cytoplasm is clear, closely vacuolated and contains very little chromatic staining material. The contents of the ventriculus, has been undergoing a slow degeneration. By the 96th hour the fibrous nucleated nature of the original "yellow body" has disappeared and a coarse granulated irregular mass fills the lumen. Absorption of some of the fluid contents follows, accompanied by a further granulation of the larger particles of debris. The body of the posterior tissue plug has been changing. After the 144th hour an internal degeneration has set in and its definite cell structure disappears. The enclosing tissue walls, however, remain intact, (Fig. 52, t. p.). In the pupa of 168 hours the mass is still coarsely granular, yellowish brown in color and forms a coherent body lying in the posterior region of the ventriculus. In some cases it retains its integrity until after the opening of the pyloric valve. Usually this solid mass breaks up into scattered granular to flocculent particles about the 246th hour. Meanwhile, at the 264th hour the pyloric valve opens and the entire contents of the ventriculus passes into the hind-intestine, (Fig. 53).

In sections from pupa 114 hours old and older there may be seen very small single replacement cells between the bases of the epithelial cells. They increase slightly in size with the age of the pupa and occasionally small clusters of such cells can be found. They persist in this condition through the pupal development and pass unchanged

into the imago. Although not as abundant as in the larva and early stages of the pupa these replacement cells may be found somewhat reduced and at irregular intervals along the basement membrane in the adult. They do not appear to proliferate further in the imago.

The epithelial cells begin to change from cuboidal to columnar in the 288 hour pupa. The growth proceeds slowly over the entire surface. No difference in regions can be noticed until the 348 hour pupa. The lumen at this stage has lost its distinctly circular appearance, and it has become irregular in shape. The epithelial cells in the anterior region are crowded and columnar, (Fig. 54). The cytoplasm is granular, the nucleus small and situated in the basal portion of the cell. The epithelial cells in the median region are short columnar, not closely compressed except at the angles of the ventriculus, (Fig. 55). The latter has become triradiate in shape. The lining of the posterior wall of the ventriculus is but slightly changed. It is lined with low and densely stained cuboidal cells. The cells of the anterior and median regions continue to elongate and the lumen is gradually compressed to a narrow slit-like opening, (Fig. 56, lu.).

The anterior tissue-plug is forced apart and the cardiac valve opens at the 384th hour, (Fig. 42). At this time the striated hem appears as a narrow border (Fig. 42, s. b.) along the free edges of the epithelial cells. It is between 1 to 2.5 microns in thickness. The ventriculus is now an elongated empty sac with somewhat compressed walls and open at both ends, (Fig. 43, 44, 45, 46). Within the next 24 to 48 hours the imago emerges.

In some specimens, before emergence, a substance is secreted into the ventricular cavity that appears finely granular in character. This occurs after the 384th hour and tends to distend the wall. This is more evident in the male specimens which are usually smaller than the females. It is also observed in some of the females, but generally the ventriculus is distended with air, (Figs. 44 and 45). The volume seems to increase with the age of the adult. The average seldom live over a minimum of 10 to 12 days. As the fore-intestine is empty and the insect does not feed, no additional substances enter the ventriculus.

Muscular wall. The muscular wall of the mid-intestine is so weakly developed that changes within its structure are extremely difficult to follow. No visible modifications were observed until the 96 hour pupa, which was about the end of the period of secretion by the epithelial cells. The muscles then become clear and their outline is indistinct; they are surrounded by large numbers of leucocytes which predominate in the blood at this time. By the 120th hour the larval muscles have been obliterated and a fine line of myloblasts have arranged themselves near to the basement membrane which has remained intact throughout the entire development. The myloblasts grow slowly and by the 160th and 168th hours they are fairly plain. It is not, however, until the 192nd hour that the longitudinal muscles can be definitely seen and the new circular muscles are not distinct until the 216 hour pupa. No further changes were observed to occur.

Hind-Intestine.

After the last defecation of the larva, 12 to 14 hours before pupation the lumen of the entire larval hind-intestine collapses. It then appears as a more or less straight tube extending from the pyloric valve to the posterior tip of the larval body.

The initial changes in the hind-intestine are coincident with those of the fore-intestine. Beginning between 8 and 10 hours before pupation the integumentary histoblastic discs along the posterior body wall begin to increase and displace the larval epithelial cells. Within 4 to 5 hours the forming pupal integument shrinks from the larval wall and the chitinous lining of the hind-intestine is loosened from its course. The posterior opening of the intestinal tract is very wide at this time, (Fig. 57).

With the increased growth of the integumentary histoblastic cells, the muscles of the hind-intestinal wall as well as the large sphincter muscles attached to it begin to show signs of degeneration. The process is at first most evident in the circular muscles of the larval small intestine. Their structure, 5 hours before pupation, has become finely granular, many vacuoles are present and the striations are scarcely visible. The larval nucleus remains prominent but coarsely granular, (Fig. 58, c. m.). At this time the sphincter muscles and certain body muscles begin to lose their striations and vacuolation begins near the outer edge. The striations then become irregular and finally disappear but the fibrillæ remain distinct in the larger muscles. The nuclei pass to the outer margin and lie just within the scarcolemma, which remains intact.

On pupation the larval cuticle is exuded and the chitinous lining of the hind-gut is thrown off. The result is a complete collapse of the entire lumen and the contraction of the integumentary wall in the region of the posterior opening. The histoblastic cells from the integument in this region begin to increase and form a dense cluster of cells, in some cases several layers deep. These new cells lie in direct contact with old larval epithelial cells of the posterior wall and replace them in the same manner as in the fore-intestine. At pupation the larval epithelial cells lining the hind-gut are swollen. They are coarsely granular, contain numerous vacuoles and show general signs of degeneration. The muscles of the anterior and posterior walls have begun to break up and the scarcolemma has disappeared from all but a few of the muscle bundles in the median region. The sphincter muscles have become granular in appearance, the striations persisting in only a small area and there very indistinct and irregular. The substance of the muscle is greatly shrunken and the larval nuclei line the periphery.

Although the "tissue plug" closing the opening between the mid-intestine and hind-intestine is not complete until 6 hours after pupation, the histoblastic cells in the region of the pyloric valve have increased greatly in number, (Fig. 47, hist. c.). They form a dense cluster of cells at the anterior end of the intestine. In the pupa 2½ hours old this mass of newly formed cells begins to push its way posteriorly in the

channel of the larval hind-intestine. The latter is now in a state of active disintegration in this region. The breaking down of the larval muscles and epithelial cells proceeds from the anterior and posterior and simultaneously as the new cells advance from the germinal discs (one group from the region of the pyloric valve, the other from the integumentary cells). This process continues and in the 18 hour pupa numerous leucocytes congregate about the dead muscle tissue (Fig. 59). The advancing columns of epithelial cells meet, in some cases at 24 hours after pupation, in others not until 30 hours. In either case the new cells form a narrow thin tube with nuclei parallel to the axis of the lumen. In the 24 hour pupa numerous flattened spindle-like to triangular cells appear in the blood in the posterior region near the hind-intestine. These cells, or myloblasts, arrange themselves along the wall of the hind-gut. They are very evident in the 30 hour pupa and lie parallel along the wall amidst the debris of dead larval muscles and epithelial cells. The destruction of this dead material is partly accomplished by leucocytes that surround it during the period from 18 to 48 hours. They do not attack any of the normal tissue and only seem to engulf particles that have broken out into the blood space.

At the end of 48 hours most of the larval debris has disappeared and the anterior cells lining the posterior intestine have expanded slightly. Their nuclei are still flat and parallel with the axis of the lumen. The myloblasts have united in the anterior region to form a thin multi-nucleated muscle layer that lies close to the outer edge of the new epithelial cells. In the median region of the hind-gut the lumen has commenced to expand and the nuclei of the epithelial cells lie at an angle with the axis of the lumen. This is the beginning of the large intestine of the adult, (Fig. 60). Its future structure and function show it to be really a combination of the colon and rectum. In the 72 hour pupa the lumen of this area has expanded and the region anterior to it, or small intestine, has become a narrow tube lined with a thin multinucleated synctium-like epithelial layer with compressed oval nuclei and definite muscular wall.

At the point where the small intestine opens into the expanded and somewhat thinner walled large intestine, there is gradually developed a valve-like structure. This is an ileo-colic or mid-intestinal valve and begins to form in the 120 hour pupa, (Fig. 61, il. col. v.). It is first indicated by an elongation of the nuclei and an outgrowth of the cell wall into the lumen. The cells appear in many respects similar to the histoblastic cells. They proceed to grow and extend as a multinucleated irregular protuberance into the anterior growth of the large intestine, (Fig. 62, il. col. v.). The growth is completed at about the 216 hour, (Fig. 63, il. col. v.). Although occupying the position of a valve the tissues do not appear to close the lumen at any time.

With the beginning of a distinct differentiation between the fore and hind parts of the posterior intestine in the 120 hour pupa, there follows a uniform expanding of the wall of the posterior region from the ileo-colic valve to the anal aperture. The epithelial stratum in the expanded

region, which before showed a rather irregular margin is now pulled out into a very narrow line with smooth border, (Fig. 64).

At the same time as the ileo-colic valve is forming certain epithelial cells along the wall of the posterior portion of the hind-intestine begin to show similar modifications. The nuclei elongate, increase in number and the cell walls protrude into the lumen. In the 120 hour pupa several of these areas may be observed, but at that time they appear only as thickenings of the epithelial stratum, (Fig. 65). In the 144 hour pupa a basal multinucleated area is seen and an anterior, typical glandular structure, (Figs. 66 and 67), with several nuclei, oval to irregular in shape and others elongate and spindle-like. The cell walls are partly visible; the cytoplasm is clear and lightly granular. These outgrowths are true rectal glands. They increase slowly in size and reach their maxim dimensions in the 168 hour pupa, (Fig. 68). In many cases a distinct lumen can be seen between the basal and anterior structure and a thin layer of chitin over the free surface. In *Homaledra* there are six of these rectal glands arranged irregularly on the wall in the posterior region of the hind-intestine. No further change was observed in the structure. In the imago of 3 to 10 days old, they appear slightly reduced in size but essentially the same in structure.

Although the large intestine begins to expand in the 120 hour pupa, the pyloric valve does not open until the 264th hour. Just previous to the 120th hour, the posterior wall of the hind-intestine is completed and is very similar to that of the anterior region. The epithelial stratum is slightly thicker, the nuclei are larger and more granular and the muscular layer distinct but weakly developed. In the 258 hour pupa a delicate chitinous membrane is being formed along the entire course of the large intestine from the ileo-colic valve to the anal opening. At the same time, the growth of a heavy muscular wall about the posterior genital tubes causes a bend in the course of the posterior third of the large intestine and also a compression of the lumen. The compressed portion of the intestine becomes a narrow tubular structure and may be considered as the rectum or anal tube, (Fig. 69, a. t.). As it is merely a narrow passage way to the exterior and does not serve as a storage place for any waste material, it does not represent the characteristic rectum of insects. The function of storage is associated in *Homaledra* with the large intestine. The presence of the glands in the former structure further add to the possibility that the posterior tube is nothing more than an extension of the large intestine and should be considered only as a "rectal tube."

On the opening of the pyloric valve the contents of the ventriculus pour slowly into the large intestine and gradually distend it, (Fig. 69). This material is retained in the thin chitinous membrane that lines the cavity. The wall of the posterior region, or rectal tube, collapses and the chitinous lining of its wall is bunched up into one or more compressed lumps or plate-like structures (Fig. 69, chi. i.) that completely block the median to posterior end. In most specimens there are several folds in the wall just posterior to the opening of the large intestine. Further granulation of the intestinal debris takes place in the large

intestine. It remains in this chamber until the emergence of the imago (i.e. from the 264th hour to a time varying between the 402nd and 432nd hour of pupation). The chitinous plug in the anal aperture often adheres to the chitinous wall of the pupa. On the emergence of the adult this is pulled out and exuded with the pupal case.

Shortly after the imago emerges part of the finely granular substance in the large intestine is voided as the meconium. In many adults the greater part of this substance seems to be retained. This proved to be the case with laboratory raised specimens as well as with those collected from the field. Even in specimens 10 days old the large intestine was often filled, although the fore and mid-intestine was filled with air. In all probability it serves as a source of nutriment to the adult as the fat body in the latter is greatly reduced. Furthermore, dissections show a gradual reduction or absorption of this substance during the life of the imago in cases where the contents has not been voided at eclosion. Verson (1905) has shown that these degeneration products are voided through the anus in the silkworm. Tiegs (1922), in *Nasonia* found them to be stored in the posterior intestine. He further attributes considerable nutritive value to the intestinal debris and states that "if the observations of Verson are correct, the process offers a curious type of inefficiency—the waste of certain useful storage materials—which does not occur in *Nasonia*."

Salivary Glands.

Spinning Glands: The spinning glands are morphologically labial glands but homologous with the true salivary glands of other insects, (Imms, 1925:407). The anatomy and histology of these glands have been studied in many Lepidopterous larvæ: Helm, (1876), Englemann (1880), Blanc (1889, 1891), Gilson (1890), Verson and Bisson (1891), and more recently by Tanaka (1924).

The spinning or silk glands of *Homaledra* are very similar to those of other larvæ of the same order, (Figs. 25, 26, and 70). There is a thin outer membrane or tunica propria and an inner chitinous lining, the tunica intima, (Fig. 71). In the secreting glands the tunica intima has distinct transverse striations. The epithelial cells of the glandular area are very large, polyhedral in shape and possess curious irregular shaped nuclei, (Figs. 70 and 72). As the glands produce their secretions the epithelial cells flatten out and the lumen becomes filled with a mass of clear viscid appearing globules, (Fig. 71). After the liberation of the silk, the epithelial cells again expand and the cytoplasm contains many large empty vacuoles, (Fig. 70).

In the early prepupal stage of *Homaledra* the contents of the spinning glands are used in preparing the silken tunnel, or cocoon, in which pupation takes place. Therefore, just before pupation the glandular contents are reduced, (Fig. 73). The epithelial cells are somewhat contracted and the cytoplasm is finely granular in character. At pupation a further reduction has occurred and the glandular region is slightly lobulated. Although still irregular the nuclei have contracted

and are more or less globular in shape. Further contraction occurs along this region, and in the 12 to 18 hour pupa the anterior region is deeply lobed and densely granular, (Figs. 74 and 75). At the same time the nuclei in the larger glandular area have begun to disintegrate. Many small vacuoles appear in the cytoplasm and the cell walls break down, (Fig. 76). In the 24 hour pupa large clear areas have formed below and at intervals along the periphery of the tunica propria, (Fig. 77). The identity of the cells has been lost and the entire contents converted into a mass of disintegrating nuclei, coarse granules and vacuoles. These final stages in histolysis do not occur in the salivary ducts. The walls contract after pupation, the nuclei become globular to irregular and large vacuoles appear throughout the cytoplasm, (Fig. 78). The lumen, although contracted is not obliterated as it is in the glandular area.

Between the 24 to 27 hour pupa leucocytes begin to congregate along the walls of the glandular region, (Fig. 77, leu.). They lie along the wall at first but as the latter is destroyed, they penetrate into the disintegrating tissue. Phagocytosis begins in the posterior and median region and proceeds anteriorly to the base of the salivary ducts, (Fig. 79). A few scattering remains of the nuclei may be found in the 48 hour pupa but by the 72 hour pupa the visible signs of the organ have disappeared.

The salivary duct continues to shrink in diameter and appears to undergo a complete reduction in the size of its parts, (Fig. 78). No leucocytes were observed attacking it at any time. Following the granular disintegration and later phagocytosis of the glandular region the ducts remain as very slender glandular-like tubes extending into the median region of the thorax. The lumen is very narrow, the epithelial cells very flat and the nuclei very irregular, like miniature representations of the former salivary nuclei, (Fig. 80). By the 120th hour these tubes have reached their final stage of metamorphosis and persist unchanged through the remaining pupal period and pass into the adult. These structures in the adult moth appear to be non-functional, as they show no cellular changes in adults of various ages. This might be expected as the adult does not feed. In the imago these structures may be termed "thoracic glands" as they resemble the "Thoracaldrusen" described by (McDunnough, 1909:351) in the adult of *Chrysopa perla* L.

The destruction of the spinning glands in *Homaledra* resembles that described by Tiegs, (1922:449, 450) in *Nasonia* (Hymenoptera) and by Pérez (1910:139–150) in *Calliphora* (Diptera). The size of the organ and relatively large component cells greatly facilitate the observations. That the process is first one of chemical action resulting in death and granular degeneration of the parts, followed by phagocytosis, there can be little doubt. Tiegs (1922:450) states in regard to *Nasonia* "salivary glands, in their degeneration, offer as clear an example of phagocytosis as it is possible to wish for. But their death, degeneration, and even partial disintegration previous to phagocytosis are equally clear."

Functional Salivary Glands: The maxillary and mandibular glands of the larvæ undergo a similar degeneration to the spinning glands. This appears to be entirely of chemical origin as they are not attacked by the leucocytes. Their complete disappearance is accomplished by the 10th hour of pupal life.

Malpighian Tubes.

The Malpighian tubes in *Homaledra* persist from the larval to adult stage, but exhibit some modifications in structure, (Figs. 1, 2, 43, 44, 45, 46). The larval urinary ducts, however, are completely destroyed and remade into somewhat larger structures in the imago, (Figs. 43, 44, 45, 46: ur. d.).

In the actively feeding mature larva the Malpighian tubes (Figs. 1 and 2, palp. t.) appear on the surface to be composed of uniform rectangular cells which in cross section show as long low cuboidal epithelial cells, (Figs. 81, 82, 83). The nucleus is usually irregular in shape and may consist of a number of parts, (Fig. 81, nuc.). In cross section these seem to lie in the median region of the cells, (Fig. 83). In the distended tubes an inner and outer zone can be detected and in such cases the contents of the lumen appear finely vacuolated with minute granules throughout its structure. Numerous small crystals may also be found, (Fig. 84). In partially filled tubes the basal regions of the cells appear denser and more granular than the region near the lumen which is finely vacuolated, (Figs. 82 and 83). The enveloping membrane of tunica propria is distinct and shows plainly in all the preparations.

Three hours before pupation the walls of the tubes have developed an undulating outline and many of the cells have expanded so as to produce a somewhat lobulated effect. The individual cell walls have become very indistinct and are almost obliterated in some cases. The nucleus has contracted into an irregular fibrous-like mass and the cytoplasm is granular throughout with numerous clear vacuoles near the peripheral wall, (Fig. 85). At pupation each nucleus appears as a densely chromatic irregular to oval mass, (Fig. 86), the vacuoles along the outer wall have increased and many have coalesced. The finely granular material has been pushed to the lining of the lumen. The latter is still discernable. In the six hour pupa there is no apparent change but in the tenth and eleventh hour pupa the large vacuoles have disappeared from the cellular layer, the nuclei have lost their fibrous character and appear as dark granular masses. The lumen has again expanded and shows a narrow epithelial margin of finely granular to very minute vacuoles and nuclei scattered at intervals along its length. The entire diameter of the tubes is greatly reduced. No further changes occur in the structure of the tubes except that the nuclei in the imago become more prominent and definitely oval in outline. The cytoplasm also becomes more granular and staining shows the presence of more chromatic material.

The urinary duct of the larva is a tubular structure lined with an irregular multinucleated layer of epithelial cells, (Fig. 87, ur. d.). At

the entrance to the tubes the epithelial stratum forms a small infolded lip or valve in which the nuclei are more numerous, (Fig. 86, v.).

The same degeneration processes that destroy the larval hind-gut seem to bring about the elimination of the urinary duct. The larval epithelial cells lining the wall break down in the same manner as that of the intestine and new histoblastic cells push in to occupy their place, (Fig. 47). Between the 2nd and 3rd hour after pupation, the histoblastic cells from the pyloric valve begin to push their way around the oriface of the larval urinary duct, (Fig. 88, hist. c.). They grow and proliferate in identically the same manner as those in the intestine. The epithelial layer is completed at the same time as that of the small intestine. The muscular wall is formed in the same manner and also coincident with the anterior intestinal wall. The oriface leading into the intestine remains as a small circular aperture between triangularly compressed walls, (Fig. 89).

The Malpighian tubes of the imago loop about the mid-intestine, (Figs. 43, 44, 45, 46, malp. t.). Their walls are smooth and in dissected specimens they appear as dirty white tubes. The process of histolysis and histogenesis has resulted in the formation of delicate thread-like structures somewhat similar to the larval organs but greatly reduced in size in both diameter and length. The malpighian tubes in the adult end over the extreme anterior region of the small intestine.

COMPARISON OF HOMALEDRA WITH OTHER FORMS

Many careful investigations have been conducted on post-embryological developments in insects since the memoir on the blow-fly (Calliphora) by Weismann in 1864. These studies have resulted in some divergent ideas relative to the metamorphic changes occurring within the insect body. The present study of *Homaledra* corroborates the views of many of the more recent workers in other groups. Only a brief comparison of some of the previous findings can be included here. The work is extensive and bibliographies on the subject are voluminous. Each species offers certain modifications, although certain groups are more or less consistent; methods of technique and quality of material have been very variable and certain misrepresentations have been possible.

Weismann (1864) observed that the larval epithelial cells of *Calliphora* passed into the lumen of the digestive tract and were replaced by areas of cells which he called "imaginal discs." The disintegration was accomplished by certain rounded cells, named by him "Kornchenkugeln." Ganin (1876) found imaginal "nests" in certain Dipterous larvæ at the end of the mid-gut and stated that the imaginal mid-gut epithelium

was formed from these. In 1883, Metschinkoff working on Muscid pupa explained the destruction of larval tissues by phagocytes, but these were later shown by the researches of Kowalevsky (1885) and Van Rees (1888) to be engorged leucocytes. Kowalevsky also showed the presence of an imaginal ring of generative cells at the junction of the fore-gut and mid-gut in certain *Chironomus*, *Corethra*, and *Culex* species. Other workers on Diptera to confirm the presence of imaginal rings in the fore- and hind-gut and replacement cells among the epithelial cells of the mid-gut were Hurst (1890), Vaney (1902), and Thompson (1905). Although Snodgrass (1924) did not study the post-embryological changes in *Rhagoletis pomonella* Walsh (Diptera), he makes the general statement that the fore and hind-gut epithelium is replaced from imaginal buds in the intestinal wall. Thompson (1905), was one of the first to doubt the presence of phagocytosis in the alimentary canal of certain *Culex* and *Anopheles* larvæ, upon which his investigations were based.

The earlier workers interpreted phagocytosis generally as phagocytosis of living tissues. Berlese (1901) claimed that some internal disintegration must precede the activity of any leucocytes or amoebocytes in the blood.

Later Metalnikoff (1908) showed the destruction of the muscles of the alimentary canal in the wax moth *Galleria mellonella* by large numbers of leucocytes.

Pérez (1910) attached considerable importance to "les spheres des granules" in the destruction of larval tissue, but Poyarkoff (1910) working on a Coleopterous form *Galeruca* differentiated between phagocytic histolysis and cellular rejuvenation.

In the Hymenoptera, Pérez (1910) has shown in *Polistes gallica* that the epithelial cells of the mid-gut are replaced by certain cells at their base. Oertel (1928) working with the same order, showed the presence of imaginal rings and replacement cells in the honeybee. Matheson (1912) observed that the larval cells in *Corydalis* (Neuroptera) became active and formed the lining of the imaginal fore-gut. In the order Thysanoptera, Muller (1927) showed the presence of a fore and hind imaginal ring that proliferated cells to form the fore and hind-gut respectively, with replacement cells lining the walls of the mid-intestine.

Many workers have disclaimed the exclusive importance of the leucocytes in destroying the living or dead tissue. The theory of degeneration, which involves the preliminary chemical dissolution and death of the tissue before destruction by these cells has been believed by many workers for a long time. Recent studies by Tiegs (1922), on the Chalcid *Nasonia*, Müller (1927) on *Parthenothrips dracaene* and Oertel (1928) on *Apis mellifica* fully confirm this theory. The present study of *Homaledra* shows a definite chemical degeneration followed in some organs by a rejuvenation, in others by a dissolution and partial absorption by leucocytes.

SUMMARY

1. The present investigation was undertaken with the view of studying certain morphological changes that occur in Lepidoptera, especially in reference to certain points of metamorphosis that have been demonstrated in some of the other orders.

2. A brief historical survey of the principal workers on the alimentary canal in Lepidoptera is included. Only a few post-embryological studies have been made on members of this order. Mention is made of some of the students of other groups.

3. The species selected for study was *Homaledra sabalella* Chambers, the palm-leaf skeletonizer of Florida and certain of the West Indies. The life history has recently been studied by Creighton (1929). The pupal period extends from 17 to 20 days. Notes on the habits and life of the larvæ are included.

4. All specimens used were collected and prepared at Gainesville, Florida, where the species is very common. Exact methods of securing pupa of the correct age are described as well as the technique of preparing slides.

5. The digestive system of the mature larva is a somewhat straight tube extending throughout the length of the body. The buccal cavity is rather definite and leads into a short and narrowed pharynx, easily distinguished by its characteristic overlapping lateral folds, bristles, and dorsal chitinous plates.

The oesophagus begins at the supra-oesophageal ganglion and passes into an expanded proventriculus. The latter joins the ventriculus at a distinct cardiac or oesophageal valve in which is found a ring of histoblastic cells.

The ventriculus is elongate, tubular, with characteristic epithelial cells with small replacement cells at the bases. A pyloric valve, also with a ring of histoblastic cells, separates the ventriculus from the hind-intestine.

The ileum is divided into an anterior and posterior chamber, separated by a very prominent ileal valve. The urinary ducts open into the lateral walls of the anterior chamber.

The colon, though normally short, is capable of considerable expansion. The musculature of the wall of both ileum and colon is quite complete and complicated. The colon empties into a short tube, or rectum, which passes to the anal aperture. The median and posterior wall of the rectum is lined with bristle-like projections from the chitinous intima.

6. The salivary glands in *Homaledra* are modified to form two elongate, often folded, spinning glands. These may extend almost the entire length of the body.

The functional salivary glands consist of the mandibular and maxillary glands.

The mandibular glands are small elongated structures lying on the inner face of each mandibular muscle. The maxillary glands are tubular structures lying laterad of the spinning glands on the floor of the buccal cavity.

7. The malpighian tubes are six in number and consist of two sets, each opening into a urinary duct, which in turn opens into the anterior chamber of the ileum.

8. The fore-intestine is formed anteriorly by the proliferation of the integumentary histoblastic discs that develop in the prepupa between eight to ten hours before pupation. Posteriorly it is formed from proliferating histoblastic cells in the region of the cardiac valve. As the histoblastic cells develop the larval oesophageal cells degenerate. This appears to be entirely a chemical process and does not involve the action of any phagocytes. The two columns of histoblastic cells unite and form a muscular wall which also undergoes degeneration.

The formation of an oesophageal diverticulum is traced from its beginning in the 60 hour pupa to its completion in the 384 hour pupa.

9. Just before pupation the larval epithelium of the ventriculus is cast into the lumen and a new epithelial wall produced by the proliferation of the replacement cells which lie

at close intervals along the inner surface of the ventricular wall. The replacement cells of the ventricular epithelium are present in the larva, pupa, and adult. The number is indefinite but they often occur as close as every second to third epithelial cell, or as far apart as every fifth to eight epithelial cell. They are always located at the base of these cells. When single they may be triangular, hemispherical, or spindle- to vase-like in shape. In the median and posterior portions of the ventricular wall, they often occur in clusters or nests.

At pupation the "yellow body" is complete and occupies a large part of the ventricular lumen. Before pupation, however, an anterior and posterior tissue plug has been formed at the cardiac and pyloric valve regions respectively. Thus the contents of the ventriculus can not escape at this stage.

The newly formed epithelial cells of the ventriculus grow, change their form and many pour their entire contents into the lumen. Certain cells become loosened and along with their secretions surround the "yellow body" in the lumen of the organ. This mass of exuviated larval tissue appears to contribute some nourishment to the growing cells and is gradually absorbed, leaving only scattered granular particles remaining. On the opening of the pyloric valve at the 264th hour, the remaining contents of the ventriculus passes into the hind intestine and is stored in the colon. After some further decomposition it becomes the fluid liberated by the adult, shortly after emergence, known as the meconium.

The muscular wall of the mid-intestine also undergoes degeneration and like that of the fore-intestine is formed anew from certain cells known as myloblasts.

10. The metamorphosis of the hind-intestine begins at the same time as the fore-intestine. Integumentary histoblastic discs proliferate and gradually replace the larval epithelium in the posterior region. Histoblastic cells in the region of the pyloric valve also begin to grow and extend posteriorly and replace the larval epithelium in the anterior region. A narrow ileum is produced and a larger thin walled distensible sac-like colon. An ileo-colic valve is formed and along the wall of the colon six characteristic rectal glands are developed from areas of the proliferating histoblastic cells.

Posterior to the colon is a narrow slightly convoluted rectum or rectal tube. On the opening of the pyloric valve

the contents of the mid-intestine pass into the colon. Further progress is prevented by a chitinous plug that lies in the median and posterior lumen of the anal tube. On eclosion, however, the latter is removed with the exuviation of the larval cuticle, and after a short period of activity some of the intestinal contents are voided as the meconium. Some, however, seem to remain in all specimens and may serve as a source of nutriment to the adult, as the latter does not feed.

11. The spinning glands of *Homaledra* undergo an internal chemical degeneration. Leucocytes from the blood then attack the dead glandular areas and aid in destroying them. The ducts undergo internal changes that result in a great diminution in size, but are not attacked by the leucocytes. They persist in the imago and resemble the typical thoracic glands as described from other forms.

The functional salivary glands undergo the same degeneration that occurs in the spinning glands. They were not found to be present in the adult.

12. The larval urinary duct is completely destroyed and regenerated from proliferating histoblastic cells that form the anterior region of the ileum. The imaginal muscular walls are formed by myloblasts.

A very characteristic internal degeneration takes place in the Malpighian tubes. They are greatly reduced in size and modified in cellular structure but the form and number remain the same as in the larva.

13. A brief comparison of *Homaledra* with other forms is included. Although the writings of other workers show some variations, the present study corroborates the more recent findings. Namely that phagocytosis does not occur in the alimentary canal, but may be instrumental in destroying certain tissues such as muscles and glands after complete chemical degeneration has taken place. Furthermore, that the digestive tract of the imago is formed from the proliferation of groups of histoblastic discs and histoblastic cells arranged in definite places in the larva. The destruction of the larval cells is brought about by certain chemical changes that produce a typical degeneration and disintegration of their structure, such changes coincident with the proliferation of the new germinal cells.

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LIST OF ABBREVIATIONS.

an.....anus
a. t.....anal tube

b.....bristle
b. m.....basement membrane
br.....brain

card. v....cardiac valve
chi. i.....chitinous intima
chi. pl.....chitinous plate
c. m.....circular muscle
col.....colon
cr.....crystals

d. l. c.....degenerating larval cells
d. m.....degenerating muscle

ec. c. m....ectal circular muscle
en. c. m....ental circular muscle
epid. c.....epidermal cell
epith.....epithelium
epith. c....epithelial cell

gl. e. c.....glandular epithelial cells

h. int.....hind intestine
hist. d.....histoblastic disc
hist. c.....histoblastic cell

i. epith. c..imaginal epithelial cell
i. hist. c...integumentary histoblastic cell
i. hist. d...integumentary histoblastic disc
il.....ileum
il. col. v...ileo-colic valve
il. v.....ileal valve
i. s. z.....inner striated zone

l. c.....larval cell
l. cut.....larval cuticula
l. epith....larval epithelium
leu.....leucocyte
l. o. c.....larval oesophageal cell
l. m.....longitudinal muscle
lu.....lumen
lw.....lateral wall

m.....muscle
malp. t....Malpighian Tubes

mand. gl...mandibular gland
max. gl....maxillary gland
md.....mandible
m. int.....mid-intestine
m. v. e. c..mass of ventricular epithelial cells
my.....myloblast
nuc.....nucleus

o.....oriface
oes.....oesophagus
oes. div....oesophageal diverticulum
oes. epith..oesophageal epithelium

p. cut.....pupal cuticula
p. d. m....pharyngeal dilator muscle
per. m.....peritoneal membrane
ph.....pharynx
ph. epith..pharyngeal epithelium
p. m.....peritrophic membrane
prov.....proventriculus
py. v.....pyloric valve

r. c.....replacement cell
rect.....rectum
rect. gl....rectal gland

sal. d.....salivary duct
sal. gl.....salivary gland
s.....secretion
s. b.....striated border (or striated hem)
s. e. c.....secretion from epithelial cells
s. m.....sphincter muscle
sup. g.....supra-oesophageal ganglion
s. w.....superior wall

t. i.....tunica intima
t. p.....tissue plug
t. pr.....tunica propria

ur. d.....urinary duct

v.....valve
vent.....ventriculus
v. epith....ventricular epithelium

w. prov....wall of proventriculus

y. b.....yellow body

DESCRIPTION OF PLATES.

PLATE I.

Fig. 1. Digestive system of active, feeding, mature larva of *Homaledra*. (× 9).

Fig. 2. The same, from another specimen of the same age. (× 9).

Fig. 3. Portion of cross-section through larval pharynx to show structure of lateral and dorsal walls. Note recurved ridges with bristle-like projections on lateral wall, and chitinous plate on superior wall. (× 650).

Fig. 4. Longitudinal section through larval pharynx. Note recurved bristles on ridges projecting into the pharyngeal lumen, and a few of the chitinous plates on the superior wall. (× 450).

Fig. 5. Section through union of larval pharynx and oesophagus. Note the transition between the multinucleated pharyngeal epithelium and the oesophageal epithelium. (× 400).

PLATE II.

Fig. 6. Longitudinal section through larval oesophagus and proventriculus. Note cardiac valve formed at junction of proventriculus and mid-intestine. (× 250).

Fig. 7. Longitudinal section through wall of larval proventriculus. (× 400).

Fig. 8. Longitudinal section of triangular muscular area at junction of cardiac valve and wall of the ventriculus. (× 400).

Fig. 9. Cross section of muscular wall of the larval ventriculus (mid-intestine). (× 500).

Fig. 10. Epithelial cells from anterior region of larval mid-intestine. Note that some of the cells are in process of secretion, also the presence of small histoblastic cells along the basement membrane. (× 500).

PLATE III.

Fig. 11. Epithelial cells from median region of larval mid-intestine. (× 550).

Fig. 12. Epithelial cells from posterior region of larval mid-intestine. Note denser character of epithelial cells; also histoblastic discs. (× 550).

Fig. 13. Longitudinal section through posterior region of larval mid-intestine and anterior region of the ileum. Note pyloric valve and ileal valve. (× 150).

Fig. 14. Longitudinal section through one-half of the pyloric valve. Note cluster of histoblastic cells and adjacent enlarged glandular-like epithelial cells which make up the anterior or frontal wall of the ileum. (× 500).

Fig. 15. Longitudinal section through pyloric valve of the larva, showing valve flattened out, while digestive tract is filled with food material. (× 175).

PLATE IV.

Fig. 16. Longitudinal section through ileal valve of larva. (× 600).

Fig. 17. Cross section of alimentary canal in region of ileal valve (larva). (× 125).

Fig. 18. Part of the wall of the same enlarged. (× 600).

PLATE V.

Fig. 19. Epithelial cells lining the median region of the larval ileum. Longitudinal section. (× 250).

Fig. 20. Cross section through posterior region of ileum (larva). Note the folds in the epithelial wall. (× 125).

Fig. 21. Portion of the same enlarged. (× 600).

PLATE VI.

Fig. 22. Longitudinal section through the posterior portion of the hind-intestine (larva). (× 125).

Fig. 23. Cross section through posterior region of larval colon, (walls not distended). (× 250).

PLATE VII.

Fig. 24. One of the spinning glands from a larva of *Homaledra*. Note the character of the loop in the glandular portion. (× 10).

Fig. 25. The same, but from another larva to show the double looping of the glandular portion. (× 10).

Fig. 26. Union of salivary glands at base of ligula, in the anterior median floor of the buccal cavity. Note portion of maxillary glands on either side. (× 150).

Fig. 27. Mandibular gland from larva. Longitudinal section. (× 150).

Fig. 28. Longitudinal section through glandular portion of mandibular gland of larva. (× 400).

PLATE VIII.

Fig. 29. Longitudinal section through anterior region of prepupa. Note that the histoblastic discs of the integument have begun to proliferate and the germinal layer has drawn away from the larval cuticula. (× 175).

PLATE IX.

Fig. 30. Longitudinal section showing proliferation of integumentary histoblastic cells at edge of larval oesophagus. (× 450).

Fig. 31. The same showing extensive growth of histoblastic cells to form a new integumentary cells. (× 450).

Fig. 32. Longitudinal section in region of cardiac valve about 6 hours before pupation. Note proliferation of the histoblastic discs and beginning of the tissue plug. (× 400).

PLATE X.

Fig. 33. Longitudinal section through region of cardiac valve just after pupation. Note complete tissue plug across anterior end of ventriculus. (× 400).

Fig. 34. Anterior region of oesophagus at time of pupation. Note that the integumentary histoblastic cells have completely lined the new cuticle and have extended along the anterior portion of the oesophageal lumen. (× 500).

Fig. 35. Longitudinal section through oesophagus at its completion (72 hours after pupation). (× 200).

PLATE XI.

Fig. 36. Oesophageal diverticulum in 60 hour pupa. (× 125).

Fig. 37. Longitudinal section through region of oesophageal diverticulum and cardiac valve in 60 hour pupa. (× 250).

Fig. 38. Oesophageal diverticulum in 96 hour pupa. (× 125).

Fig. 39. The same in 120 hour pupa. (× 125).

Fig. 40. Longitudinal section through junction of oesophagus and oesophageal diverticulum in 120 hour pupa. (× 250).

Fig. 41. Oesophageal diverticulum in 168 hour pupa. (× 125).

PLATE XII.

Fig. 42. Longitudinal section through the anterior region of the oesophageal diverticulum; also union of the oesophagus and ventriculus. Note the thick walled, multinucleated structure joining the oesophagus with the ventriculus. (× 450).
Fig. 43. Digestive tract dissected from adult moth of *Homaledra sabalella*. (× 8).
Fig. 44. The same from another specimen. (× 8).
Fig. 45. The same from another specimen. Note that oesophageal diverticulum and ventriculus are inflated with air. (× 8).
Fig. 46. The same from another specimen. (× 8).
Fig. 47. Longitudinal section through pyloric valve in 6 hour pupa. Note the formation of the tissue plugs and the proliferation of the histoblastic cells. (× 400).

PLATE XIII.

Fig. 48. Cross section through ventriculus to show separation of larval epithelial cells from basement membrane. This is the beginning of the formation of the "yellow body." (× 500).

PLATE XIV.

Fig. 49. Cross section through "yellow body" and portion of wall of ventriculus (at time of pupation). (× 400).
Fig. 50. Epithelial cells from wall of ventriculus in 24 hour pupa. (× 475).
Fig. 51. Epithelial cells from wall of ventriculus in 36 hour pupa. (× 475).
Fig. 52. Longitudinal section through pyloric valve in 144 hour pupa. Note internal degeneration of the posterior tissue plug. (× 400).
Fig. 53. Opening of pyloric valve in 264 hour pupa. Note contents of ventriculus passing into the hind-intestine. (× 400).

PLATE XV.

Fig. 54. Cross section through the anterior portion of the ventriculus in the 348 hour pupa to show nature of epithelial cells. (× 350).
Fig. 55. Cross section through the median region of the ventriculus in the 348 hour pupa. (× 350).
Fig. 56. Cross section through the anterior region of the ventriculus just before eclosion. Note that the lumen may be compressed or expanded with air. This is the characteristic ventricular epithelium of the adult moth. (× 350).

PLATE XVI.

Fig. 57. Longitudinal section through posterior end of hind-intestine about 14 hours before pupation. Note the proliferation of the integumentary histoblastic cells. (× 450).
Fig. 58. Longitudinal section through portion of the ileum 5 hours before pupation. Note that degeneration processes have begun in the circular muscles. (× 450).

PLATE XVII.

Fig. 59. Cross section in region of ileum in 16 hour pupa. Note that the muscle layers are dead and numerous leucocytes have collected about them. (× 500).
Fig. 60. Longitudinal section through the hind-intestine, showing the slight dilation of the lumen and the modified arrangement of the histoblastic cells. This marks the beginning of the large intestine (colon). (× 150).
Fig. 61. Longitudinal section through the ileo-colic valve at time of its origin (120 hour pupa). (× 500).
Fig. 62. The same, somewhat later. (× 500).
Fig. 63. The same, completed, (216 hour pupa). (× 500).

PLATE XVIII.

Fig. 64. Longitudinal section through the posterior region of the hind-intestine just after the formation of the ileo-colic valve. (× 75).
Fig. 65. Longitudinal section through the colon at time of origin of rectal glands (120 hour pupa). (× 500).
Fig. 66. Longitudinal section through rectal glands in 144 hour pupa. (× 500).
Fig. 67. The same, of similar age, from another specimen. (× 500).
Fig. 68. The same, from 168 hour pupa. The rectal glands are completely developed in this stage. (× 500).

PLATE XIX.

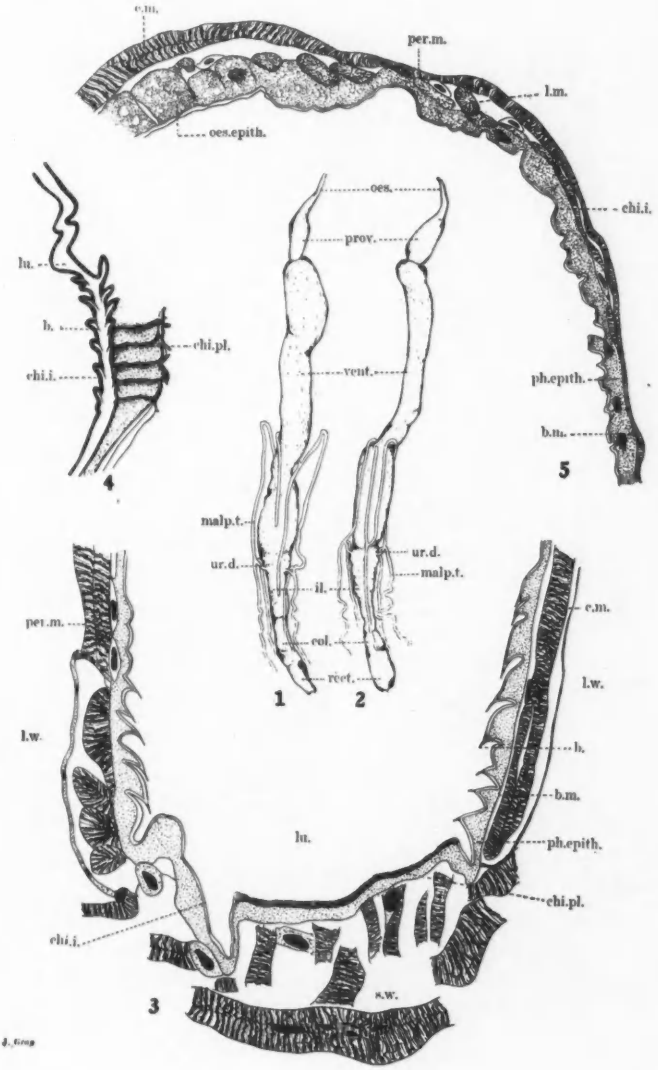
Fig. 69. Longitudinal section through the posterior region of alimentary canal shortly after the opening of the pyloric valve in the 264 hour pupa. Note that the former contents of the ventriculus have passed into the enlarged colon, but is retained in the latter by folds in the wall of the rectal tube and also by a chitinous plug. (× 85).
Fig. 70. Longitudinal section through median region of spinning gland to show nature of secreting cells. (× 375).
Fig. 71. Longitudinal section through spinning gland in secretory stage. (× 200).
Fig. 72. Surface view of cell from spinning gland to show nature of nucleus. (× 360).

PLATE XX.

Fig. 73. Longitudinal section through median region of spinning glands at time of pupation. (× 500).
Fig. 74. Cross section through anterior region of salivary glands in 12–18 hour pupa. (× 375).
Fig. 75. Longitudinal section through the same. (× 375).
Fig. 76. Longitudinal section through the glandular region of the spinning gland in 12–18 hour pupa. Note that the nuclei have begun to disintegrate and small vacuoles appear throughout the cytoplasm. (× 400).
Fig. 77. Longitudinal section through the spinning gland in 24 hour pupa. Disintegration is progressing rapidly in this stage and leucocytes have begun to attack the periphery of the tunica propria. (× 500).

PLATE XXI.

Fig. 78. Longitudinal section through salivary duct in 24 hour pupa. (× 350).
Fig. 79. Longitudinal section through spinning gland in 30 hour pupa. Phagocytes are active throughout the dead tissue of the gland at this stage. (× 450).
Fig. 80. Longitudinal section through a portion of the thoracic gland. (× 350).
Fig. 81. Longitudinal section of Malpighian tube to show surface view, (larva). (× 300).
Fig. 82. Longitudinal section through secreting Malpighian tube of larva. (× 300).
Fig. 83. Cross section through the same. (× 300).
Fig. 84. Cross section through distended Malpighian tube. Note crystal-like deposits in the lumen. (× 400).
Fig. 85. Malpighian tube from pupa, 3 hours before pupation. (× 350).
Fig. 86. Longitudinal sections through Malpighian tubes at the time of pupation. (× 350).
Fig. 87. Longitudinal section through urinary duct of larva. (× 375).
Fig. 88. Longitudinal section through neck of urinary duct between second and third hour after pupation. Note the proliferation of the histoblastic cells. (× 500).
Fig. 89. Cross section of orifice between urinary duct and anterior chamber of the ileum, just after the proliferation of the histoblastic cells, (3–5 hours after pupation). (× 450).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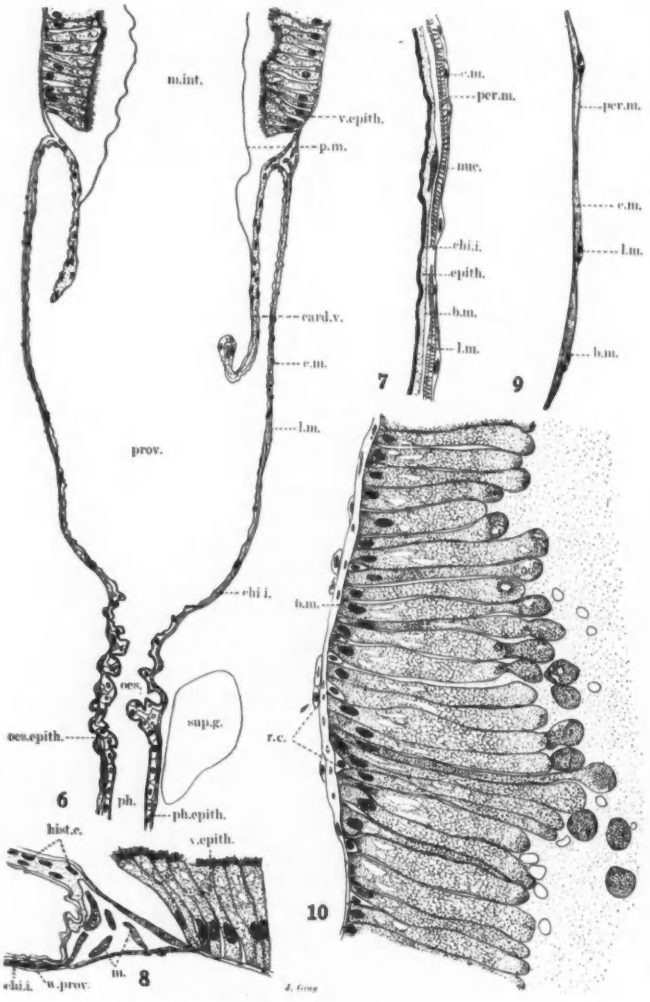
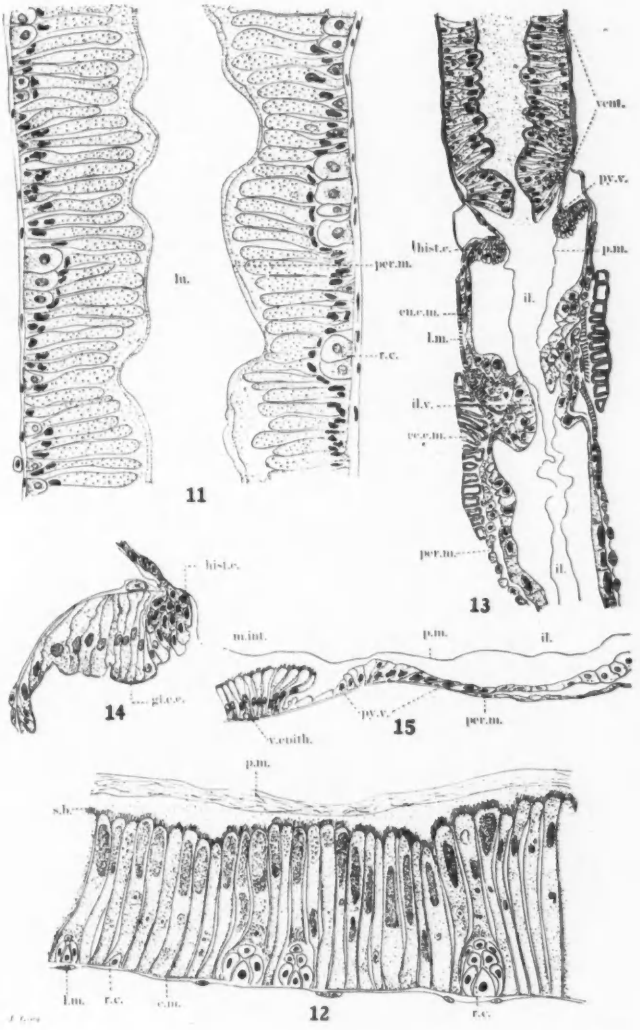
Post-Embryology of Homaledra
John Gray.

PLATE II.

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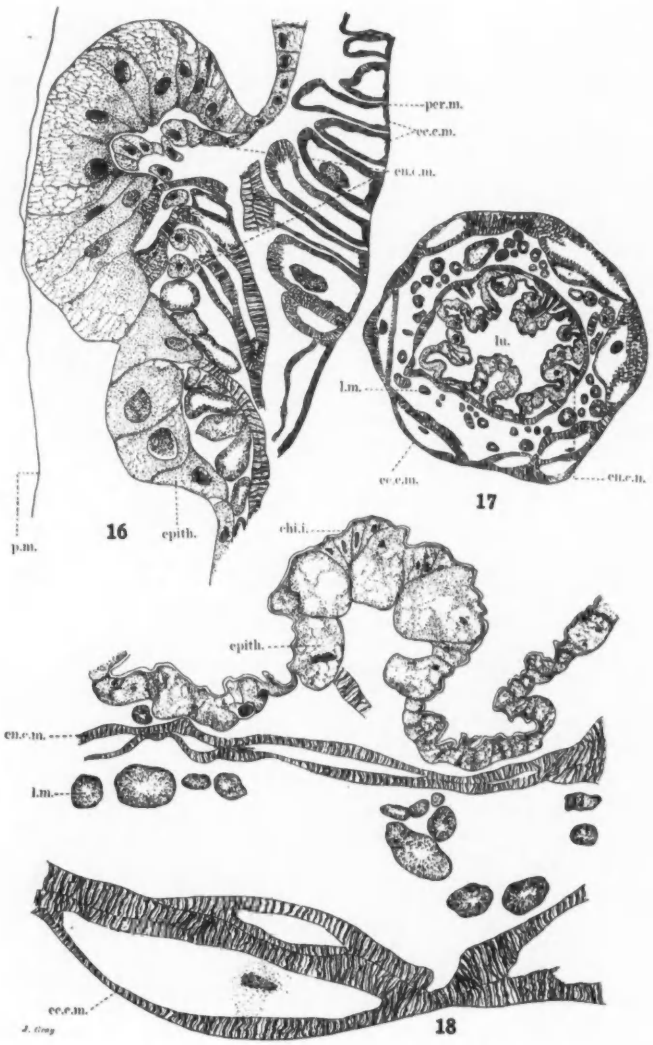
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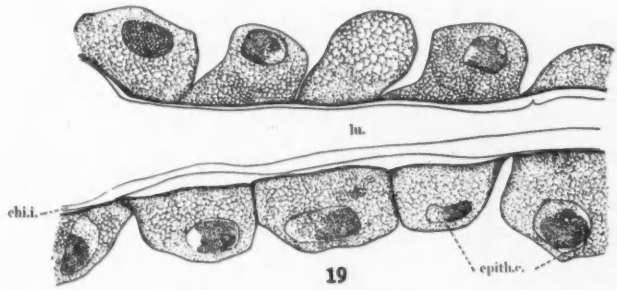

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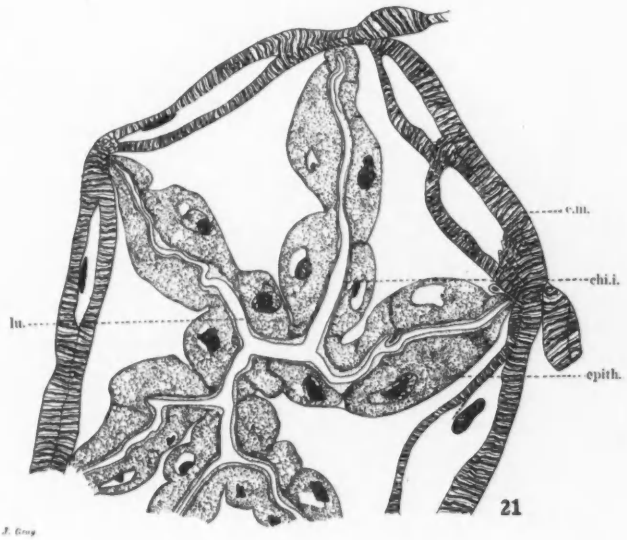

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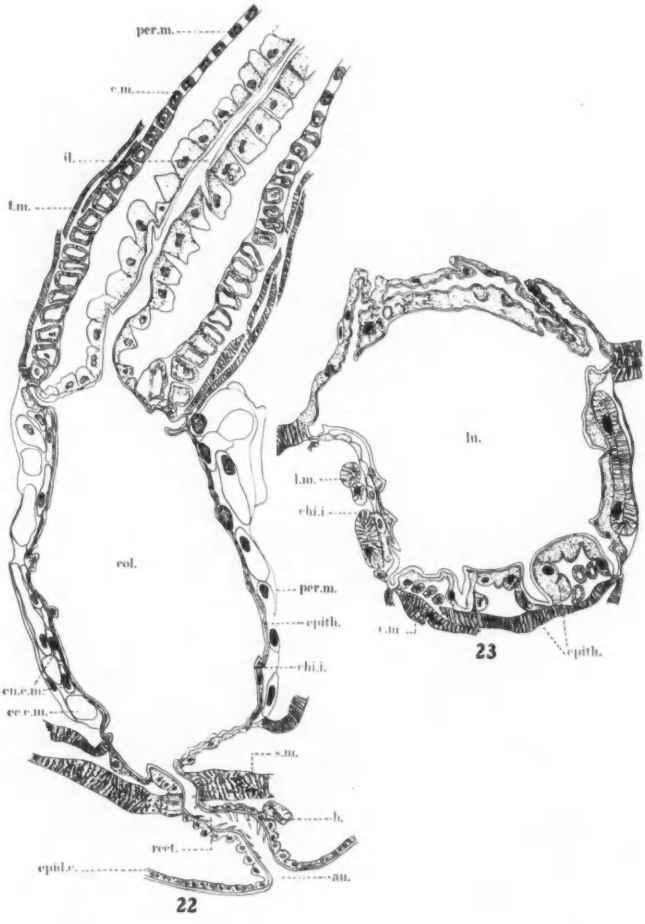
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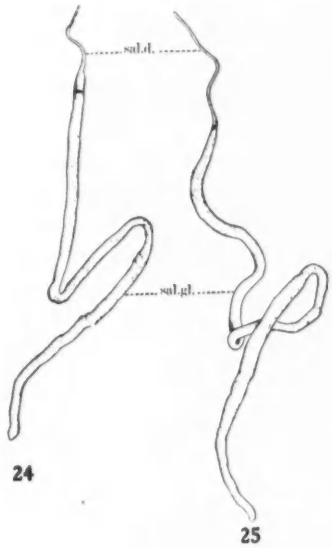

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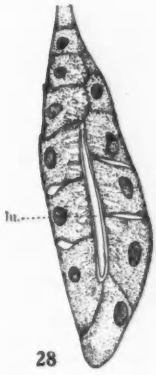

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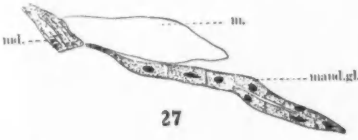

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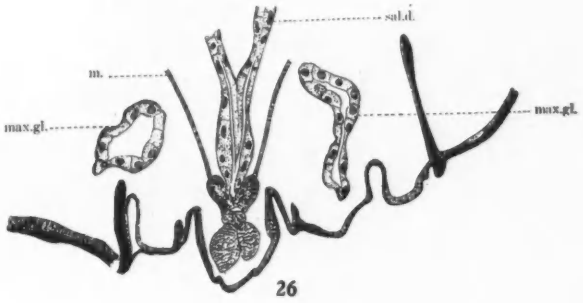

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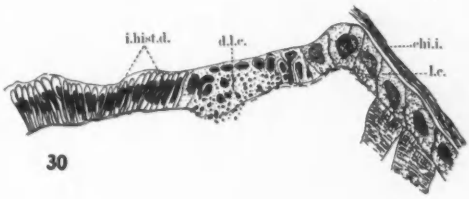

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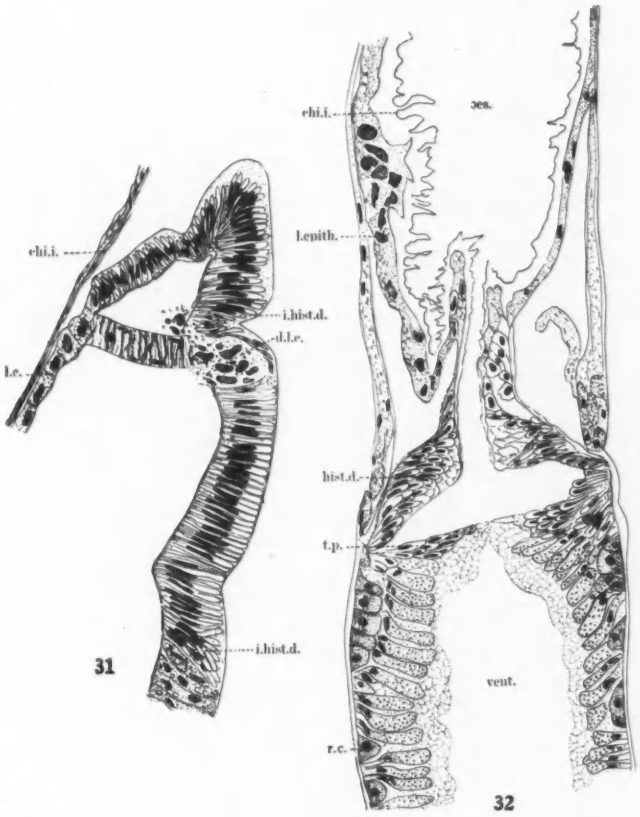

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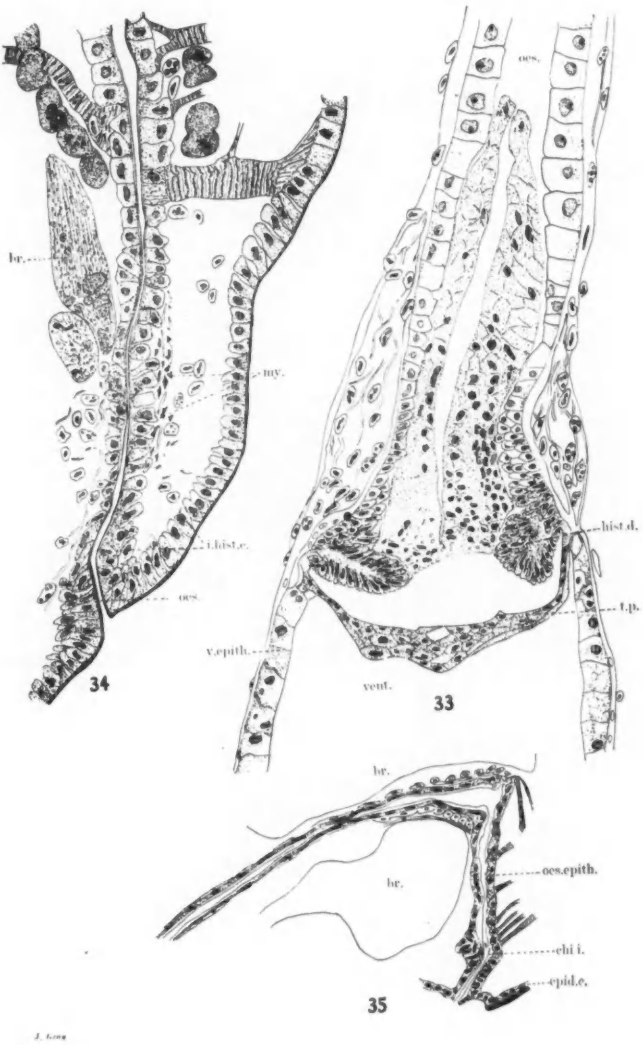
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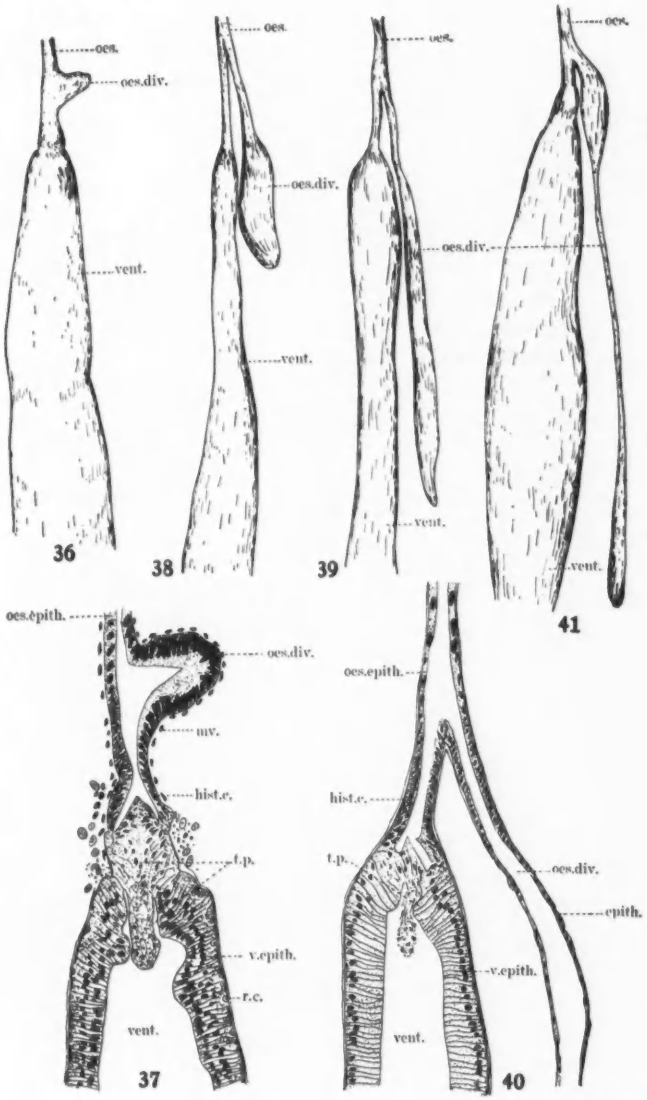
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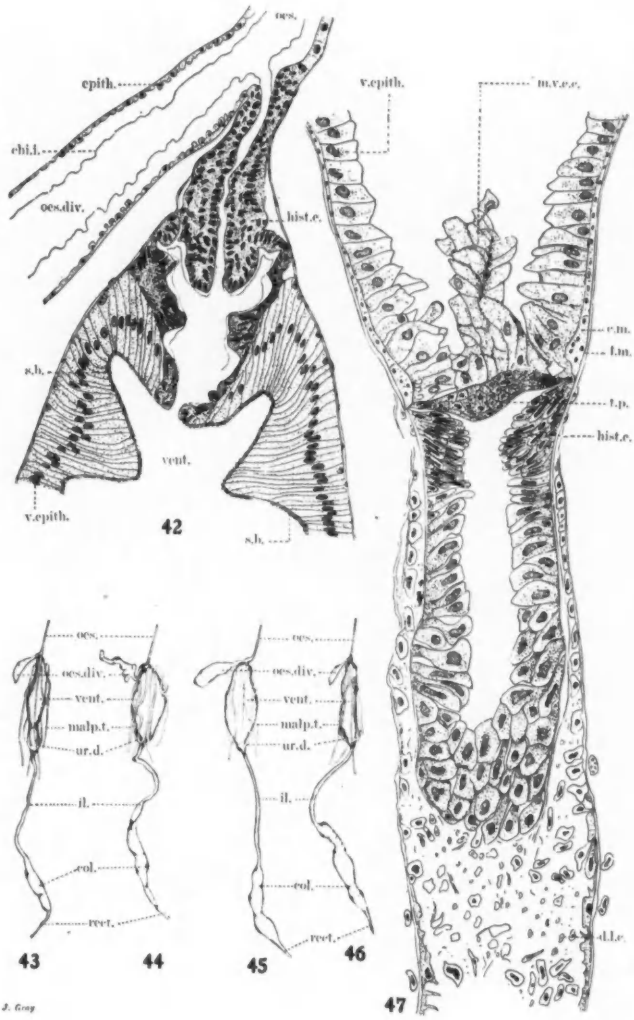
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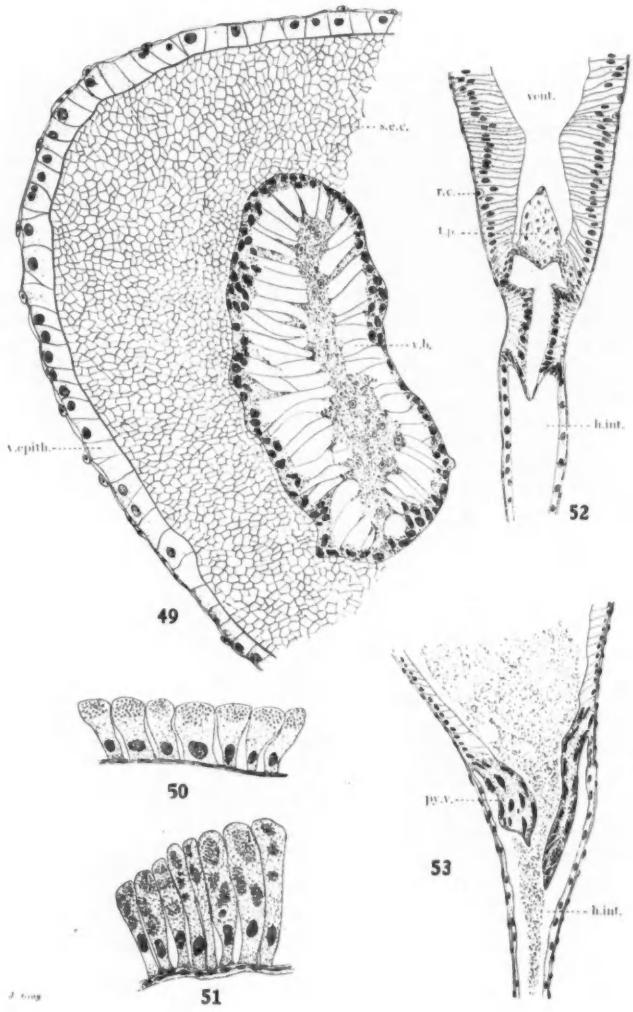
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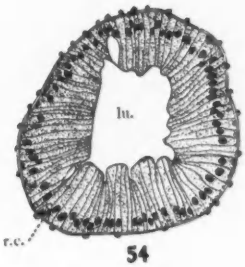

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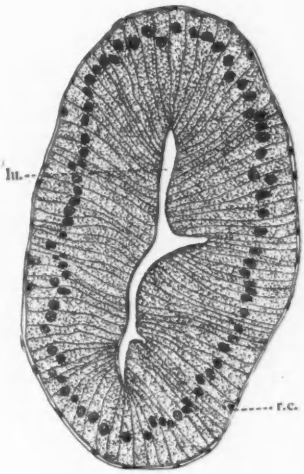

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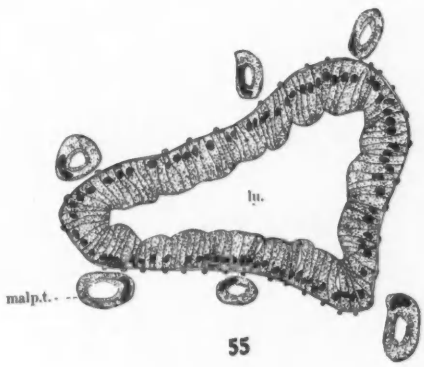

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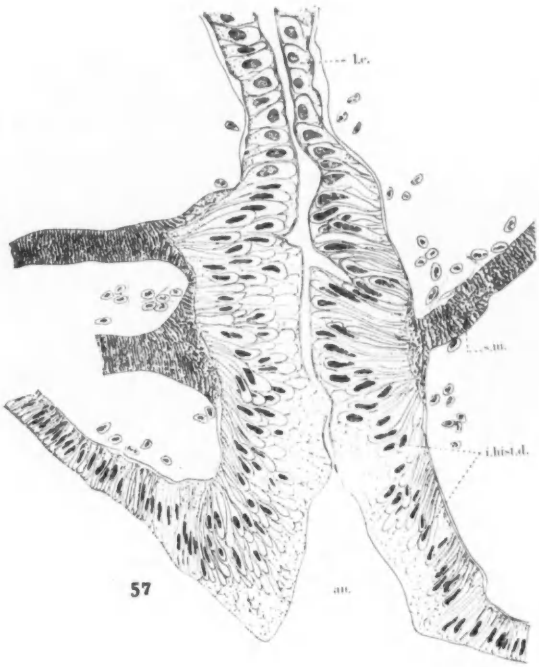
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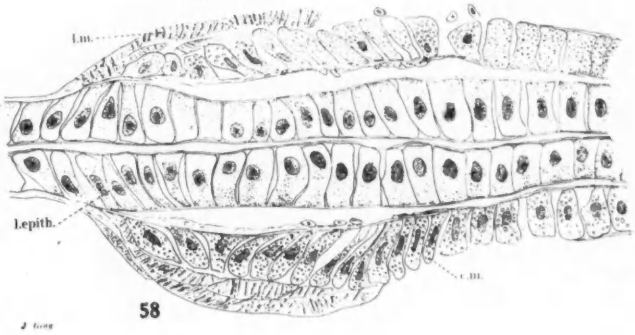
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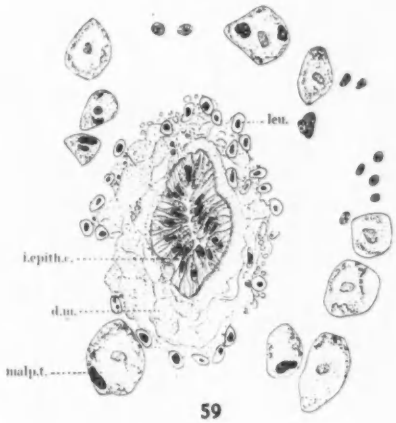
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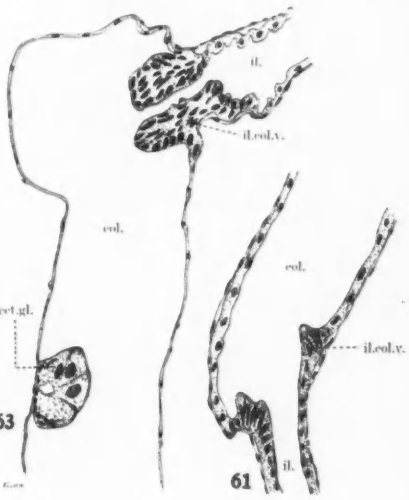
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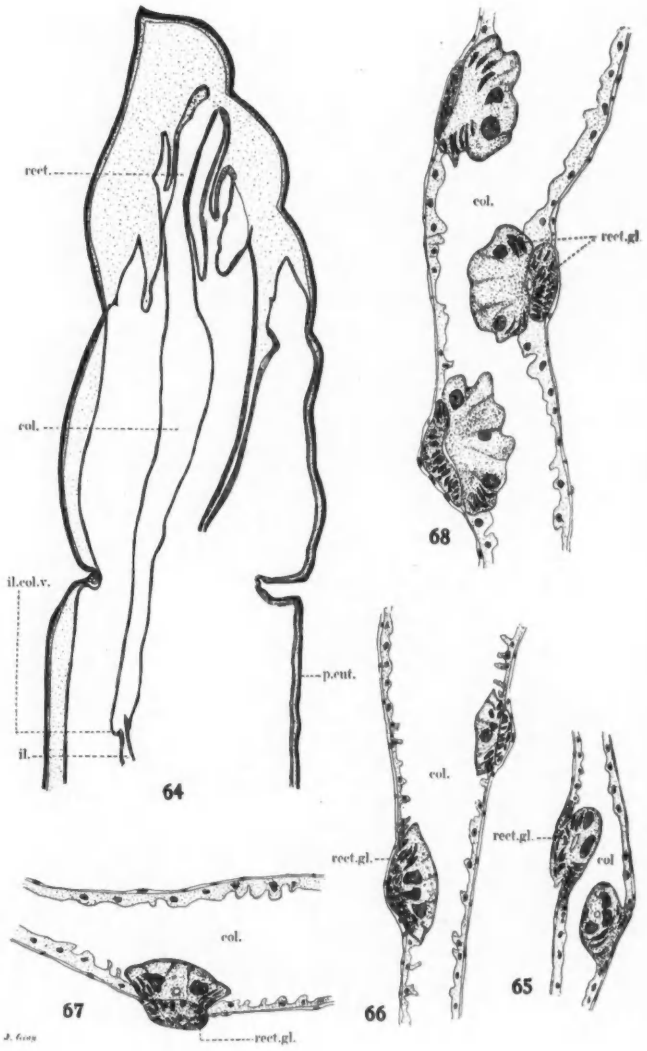
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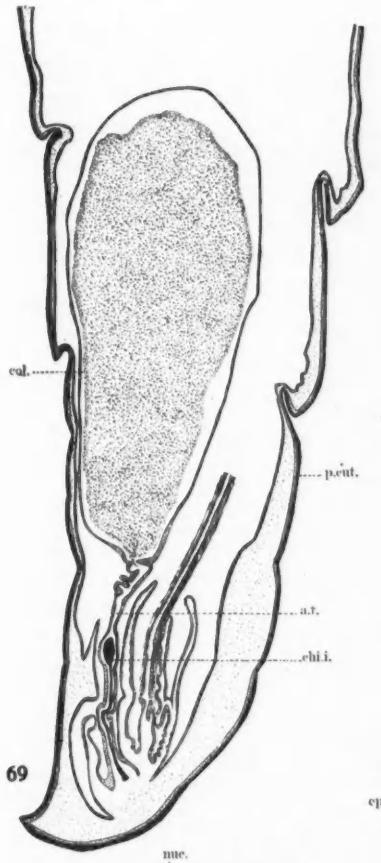
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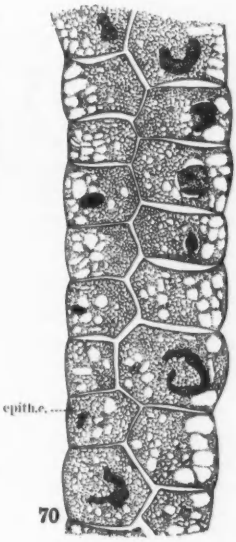
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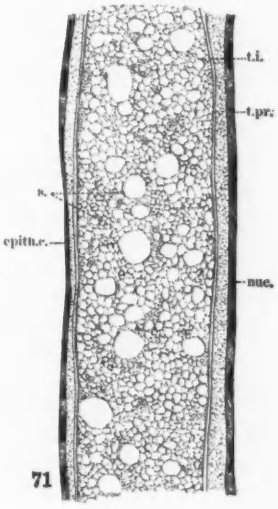
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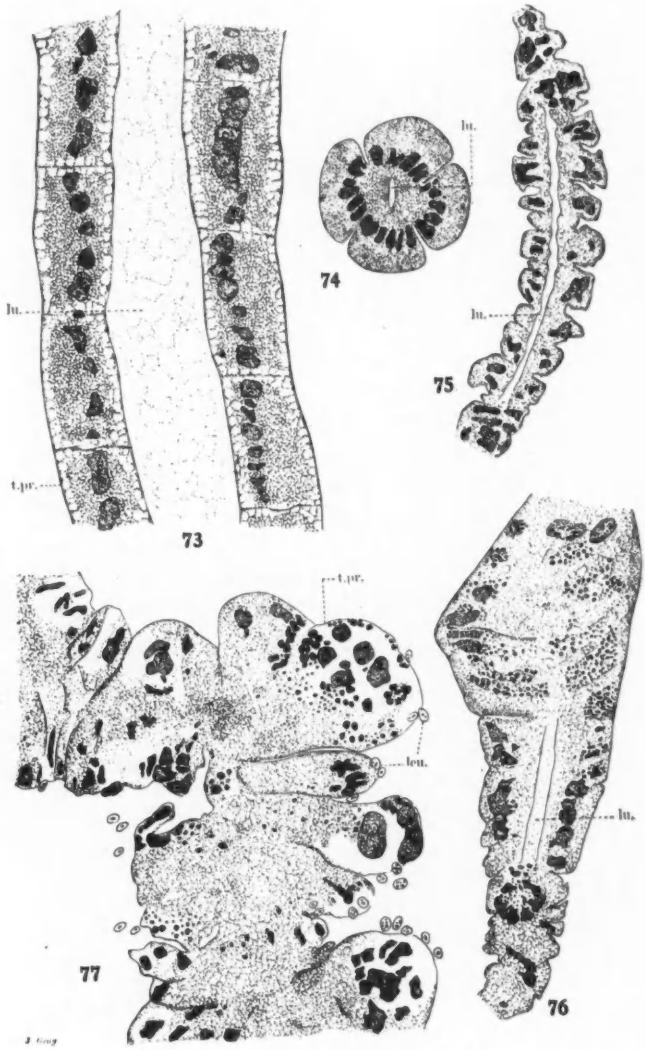
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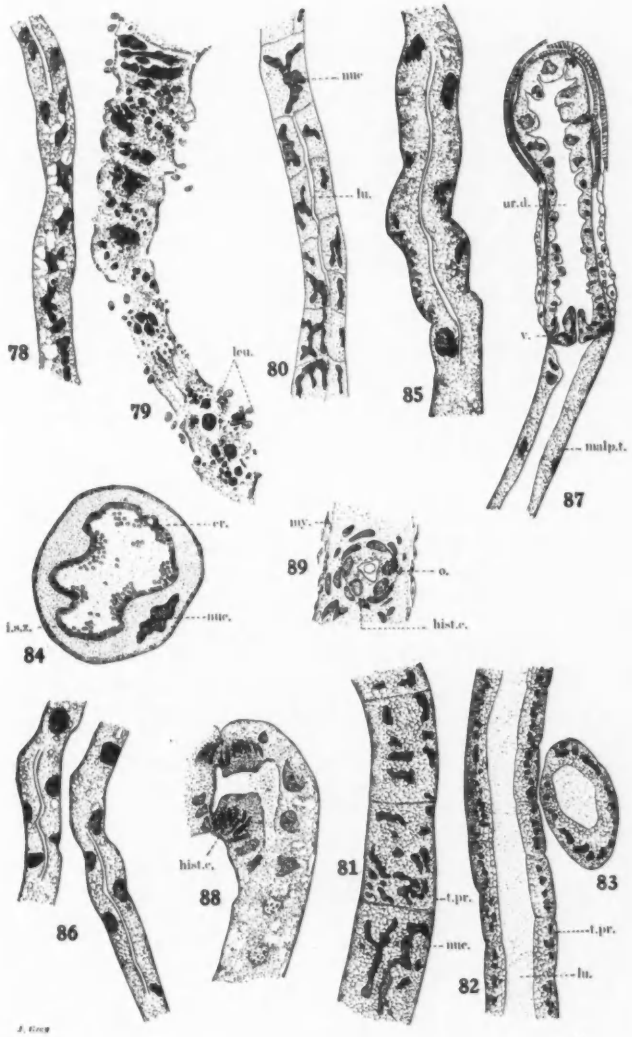
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NOTES ON THE SAWFLY SUBFAMILY TENTHREDININÆ, WITH DESCRIPTIONS OF NEW FORMS.

(Hymenoptera, Tenthredinidæ).

HERBERT H. ROSS,
Illinois State Natural History Survey, Urbana, Ill.

This paper contains descriptions of new species and varieties, and notes on some other species, of the subfamily Tenthredininæ of MacGillivray (1916), or tribe Tenthredinini of Rohwer (1911). A great deal of the material examined was collected by Dr. C. H. Kennedy of Ohio State University and by Dr. E. H. Strickland of the University of Alberta, to whom the author wishes to express his sincere thanks for their generous assistance. The types erected in this paper are deposited in the collection of the Illinois State Natural History Survey unless otherwise stated.

Genus **Laurentia** O. Costa.

Since the appearance in 1918 of Mr. S. A. Rohwer's revision of the nearctic species of this genus, it has been found that two species recently described in the genus *Tenthredo* and an older name also described in *Tenthredo*, really belong in the genus *Laurentia*, and in placing these the following synonymic list of the nearctic species has been prepared.

Laurentia diluta (Cresson).

Tenthredo dilnta Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 24. ♀.
Laurentia diluta Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1918, p. 159.

This rare species, recorded only from California, is known only from the female sex.

Laurentia rubens (Cresson).

Tenthredo rubens Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 24, ♂.
Tenthredo atravenus MacGillivray, Can. Ent., Vol. XXVII, No. 10, Oct., 1895, p. 283, ♂; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 262. *New synonymy.*
Laurentia rubens Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1918, p. 159, ♂, ♀.
Tenthredo racilia MacGillivray, Journ. N. Y. Ent. Soc., Vol. XXXI, No. 2, June, 1923, p. 112, ♂; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 263. *New synonymy.*

The opinions and surmises given by Rohwer (1918) regarding the sub-specific position of *L. edwardsii* (Cress.) and *L. aldrichii*

(MacG.) are fully adopted by the present writer. The yellow mark on the meso-episternum, which was the character used for separating both of these forms from *L. rubens* (Cress.), is subject to considerable variation, and specimens from Moscow, Idaho, with this spot almost obsolete were associated with males which were typical *rubens*. All the males examined have the meso-pleuræ entirely black. The species has been taken from various localities in California, Idaho, Nevada, Oregon, Washington, and British Columbia.

Laurentia rubens var. **ruficorna** (MacGillivray).

Tenthredopsis ruficorna MacGillivray, Can. Ent., Vol. XXV, No. 10, Oct., 1893, p. 242, ♀; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 267.
Astochus fletcheri MacGillivray, Can. Ent., Vol. XLVI, No. 3, Mar., 1914, p. 108, ♀; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 237.
Kincaidia ruficorna MacGillivray, Can. Ent., Vol. XLVI, No. 4, Apr., 1914, p. 137.
Laurentia edwardsii var. *ruficorna* Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1918, p. 159.
Tenthredo refractaria MacGillivray, Journ. N. Y. Ent. Soc., Vol. XXXI, No. 2, June, 1923, p. 113, ♀; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 264. *New synonymy.*

This variety differs from the typical form in having a yellow spot on the meso-episternum, and from var. *edwardsii* (Cress.) in having the scutellum black. It has been recorded from Idaho, Oregon, Washington and British Columbia.

Laurentia rubens var. **edwardsii** (Cresson).

Tenthredo edwardsii Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 24, ♀.
Laurentia edwardsii var. *edwardsii* Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1918, p. 158.

Characterized by the yellow, or partly yellow, scutellum. Recorded from California, Nevada, Washington and British Columbia.

Laurentia rubens var. **aldrichi** (MacGillivray).

Astochus aldrichi MacGillivray, Can. Ent., Vol. XLVI, No. 4, April, 1914, p. 137, ♀; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 237.
Laurentia aldrichi Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1927, p. 159.

The specimen described by MacGillivray, from Juliaetta, Idaho, is in almost all respects similar to var. *ruficorna* (MacG.), to which it runs in Rohwer's key (1918), but is smaller and has the antennæ entirely rufous, concolorous with the legs. It seems advisable to consider it a variety on the basis of this latter difference in color. Known only from the holotype.

Genus **Pachyprotasis** Hartig.

Pachyprotasis omega Norton.

Pachyprotasis Omega Norton, Trans. Amer. Ent. Soc., Vol. I, 1867, p. 280, ♀, ♂.
Macrophya obnata MacGillivray, Univ. Ill. Bull., Vol. XX, No. 50, Aug. 13, 1923, p. 22, ♀. *New synonymy.*

Female specimens of *P. omega* Nort. differ from specimens from England determined by Mr. R. W. Benson as *P. rapæ* (L.) in having the apical half of the posterior femora solid black and the hind tibiæ entirely black. *P. rapæ* has, in the female, the black on the hind femora in anterior and posterior bands, with the narrow upper and lower edges usually light; the black usually extends nearer to the base than in *P. omega;* and the hind tibiæ have a light narrow streak on the ventral side. The males appear identical. It may be that *P. omega* is a darker form of *P. rapæ*, but the differences in the female have been observed to be constant in over thirty specimens from widely scattered points of North America, so that in view of the continental distribution it seems advisable to retain *omega* as a distinct species.

Kincaid has identified Escherich's species *Tenthredo nigrifascia* as this species. Escherich's description, however, is vague as to the color of the legs and might possibly apply to some other similarly colored species, so that for the present I am considering it as of uncertain identity.

Specimens of *P. omega* have been examined from the following localities: 1 ♀, Straiton, B. C., May 11, 1926 (G. I. Noble); 1 ♂, Agassiz, B. C., April 26, 1927 (H. H. Ross); 1 ♂, Edmonton, Alta., July 26, 1912; 1 ♀, Edmonton, July 13, 1929 (E. H. Strickland); 6 ♂♂, 16 ♀♀, Gull Lake, Alta., June, 1929 (E. H. Strickland); 1 ♀, Aweme, Man., July 9, 1913 (N. Criddle); 1 ♂, 1 ♀, Montreal, P. Q., July 11, 1905; 1 ♂, 1 ♀, Juliaetta, Ida., May 3, 1901; 1 ♀, Black Mts., N. C., June 17; 1 ♀, Saranac Inn, N. Y., June 17, 1900.

Genus **Tenthredella** Rohwer.

Tenthredella glacialis new species.

Female.—Length, 13.5 mm. Color mostly black. Head black, including antennæ, with the following parts creamy white: palpi, outer and upper faces of mandibles, labrum, clypeus, front below bases of antennæ except fronto-clypeal suture which is black, a spot

above the base of each antenna, a fairly wide line running the entire length of the inner margin of the eye and beyond it almost to the posterior margin of the head and another line running through the postgenæ from the lower corner of the eye to a point almost midway between the upper corner of the eye and the posterior margin of the head. Thorax black with the following parts white or creamy white: anterior and lateral margins and lateral two-thirds of posterior margin of pronotum, tegulæ, central area of mesoscutellum, narrow lines on lateral portions of posterior margin of metanotum, rarely a vertical spot on mesopleuræ below tegulæ, and a spot of variable size on meta-episternum. Abdomen black with a large spot on the lateral margins of basal plates, and the posterior angles of the ventral portion of the terga, white. Coxæ, trochanters, posterior femora and posterior tarsi except apical segment, black; front and middle femora black with a white line on anterior side, narrow near base and widening towards apex; front and middle tibiæ with posterior side black and anterior side white, hind tibiæ somewhat the same but with the black completely encircling the apical fourth and the white completely, or almost completely, encircling the basal fourth; front tarsi whitish except an interrupted fuscous dorsal line, middle tarsi whitish with a black dorsal line, hind tarsi entirely black with the exception of the basal two-thirds of the last segment which is whitish. Wings hyaline, but with just a suggestion of a tawny infuscation, especially below stigma; base of stigma whitish, costal margin beyond stigma light brown, stigma and veins dark brownish black.

Head shining, only sparsely punctured; ridges and furrows only moderately pronounced; postocular area robust, not narrowed behind eye; antennæ with third segment at most only a fourth longer than fourth, and with the last two segments subequal. Thorax with anterior lobe and scutellum dull with dense fine punctures, remaining lobes more sparsely punctured and shining; scutellum shallow, feebly to moderately strongly convex; post-tergite with moderate, separate punctures covering all but the rounded median ridge; tarsal claws deeply cleft, the rays strong and diverging, the inner one short and thicker at base.

Male.—Length, 11 mm. Color essentially as in female, but with the white coloration on the mesopleuræ, legs and abdomen extremely variable, and usually much more extensive than in the female, as follows: front and middle legs, including coxæ, with anterior aspect entirely white; posterior coxæ usually with a few apical white dots; white angulate mark usually extending entirely across meso-episternum, sometimes only the anterior portion of the mark present; sterna of abdomen usually white. Structure as in female.

Holotype.— ♀, Oakwood, Illinois, July 4, 1930 (H. H. Ross).

Allotype.— ♂, same data as holotype.

Paratypes.—23 ♂♂, 21 ♀♀, including two mating pairs, Oakwood, Illinois, June 15 and 22 and July 4, 1930 (H. H. Ross). Collected in thick woods along the Salt Fork River.

The female of this species differs from *T. carolina* Rohwer in the white scutellum and the white on the venter of the abdomen. From *T. lobatus* (Norton) it differs in the white scutellum and in lacking the *V*-spot on the anterior lobe, in having a shorter postgenal white line, and in being slightly larger. The males of only a few species of this group are known, so that positive diagnostic characters can not be given for this sex. It is probable, however, that the white scutellum will be an important character for its separation.

Tenthredella fisheri Rohwer.

Tenthredella fisheri Rohwer, Proc. U. S. Nat. Mus., Vol. 45, No. 1981, May 22, 1913, p. 276, ♀.

Male.—Length, 10 to 11 mm. Color, very similar to female, as follows: head and dorsum of thorax colored as in female; pectus and a wide angular mark on meso-episternum white; front legs white with a narrow or incomplete black line on posterior surface; middle legs white with a broader, complete black line on posterior surface; hind femora black with the narrow ventral edge white or whitish, hind tibiæ black with an incomplete white ring on basal half or third; abdomen with venter white except hypopygium which is black, and with dorsum black except median dorsal yellowish white line, which is narrow on the basal plates, gradually widens until it is usually half the width of the abdomen on the fourth tergite, then becomes indistinct on the apical three terga. Wings and structure as in female.

Allotype.—♂, Oakwood, Illinois, June 22, 1930 (H. H. Ross).

Specimens examined: 17 ♂♂, 16 ♀♀, Oakwood, Ill., June 15 to July 4, 1930, collected in woods along the Salt Fork River (H. H. Ross).

The male of this species will probably be difficult to separate from the males of *T. lobatus*, *maculosa* and especially *angulifer*, but from all the males known from this group, it may be separated by the median abdominal dorsal line.

Tenthredella maculosa Smulyan.

Tenthredella lobata subspecies *maculosa* Smulyan, Can. Ent., Vol. XLVII, No. 9, Oct., 1915, p. 324, ♂, ♀.

The constancy of the characters demarking this form from *T. lobata* (Nort.), and the constancy of small color differences between large series of other species to which this is allied, give good grounds for considering *maculosa* a distinct species and not a subspecies of *lobata*. Specimens bearing the follow-

ing data have been examined: 1 ♂, 2 ♀♀, Algonquin, Ill., June 7, 1895 (W. Nason); 1 ♀, Oakwood, Ill., June 22, 1930 (H. H. Ross); 1 ♀, Battle Creek, Mich., (J. M. Aldrich); 4 ♀♀, Ithaca, N. Y., June and July, 1918; 1 ♂, 1 ♀, Put-in-Bay, Ohio, May, 1926 (C. H. Kennedy); 1 ♂, Blue Mds., Wis., June 15, 1918 (S. B. Fracker).

The three preceding species belong to a group of six nearctic species in which the compound eyes are almost surrounded by areas or lines of white or yellowish and the dorsum of the abdomen is entirely black, except for a median longitudinal pale line in *T. fisheri* Roh. *Tenthredo ventralis* Say undoubtedly belongs in this group, but owing to its meager description has never been recognized, and in addition the type has been lost. The following key will be of assistance in separating the females of the nearctic species of this group. The males of many are as yet undescribed; hence, cannot be keyed.

1. Dorsum of abdomen with a median, longitudinal white or greenish line ..... **fisheri** Rohwer
   Dorsum of abdomen entirely black 2
2. Scutellum white; V-spot absent ..... **glacialis** Ross
   Scutellum black; V-spot present or absent 3
3. Pectus whitish or yellowish; mesopleurae with a broad pale line, **angulifer** (Norton)
   Pectus black; mesopleurae black or with an interrupted pale line 4
4. Posterior angles of lateral lobes white, thus making an angular white dot on each side of scutellum; mesonotum with several longitudinal white lines ..... **maculosa** Smulyan
   Posterior angles of lateral lobes black; mesonotum with no white marks except sometimes a V-spot 5
5. Anterior lobe of mesonotum with white V-spot; apices of abdominal sterna white ..... **lobata** (Norton)
   Anterior lobe and abdominal sterna black ..... **carolina** Rohwer

Tenthredella fraternalis new species.

Female.—Length, 10 to 11 mm. Color, except legs, black with the following parts white or yellowish white: palpi, mandibles except tips, clypeus, labrum, lower portion of genæ, minute spot on inner posterior margin of eyes, posterior angles of pronotum broadly, tegulæ, minute spot on ventral corner of pronotum, large spot on meta-episternum, and postero-lateral angles of basal plates. Legs yellowish rufous, except extreme bases of coxæ which have inconspicuous black marks; front legs more yellowish than rufous. Wings almost hyaline, faintly infuscate with brownish; costa beyond stigma and basad of it, reddish brown; costa immediately basad of stigma, stigma and veins, dark brown.

Inner margin of antennal sockets considerably upraised, more so than in *T. leucostoma* (Kby.); dorsal portion of head smooth and shining, minutely and sparsely punctured; ridges and furrows well marked;

anterior and lateral lobes of mesonotum more or less opaque with small, close punctures, post-tergite with quite large, distinct punctures except for the median ridge which is carinate and shining; tarsal claws cleft, the inner ray slightly the shorter.

Holotype.— ♀, Waterton, Alberta, July 12, 1923 (E. H. Strickland). Deposited in the Canadian National Museum.

Paratype.—1 ♀, Field, British Columbia, July 26, 1906. In the author's collection.

This species differs from *T. leucostoma* (Kby.) in having the hind tibiæ and tarsi rufous, and the cheeks yellow; from *T. mellipes* (Roh.), to which it is probably most closely related, in having the cheeks and collar yellow, and from *T. ruficollis* (Harrtn.) in having the coxæ rufous and the cheeks yellow.

Tenthredella rufopedibus (Norton).

Tenthredo rufopedibus Norton, Proc. Ent. Soc. Philadelphia, Vol. III, 1864, p. 15, ♂.
Tenthredo rubricosa MacGillivray, Univ. Ill. Bull., Vol. XX, No. 50, Aug. 13, 1923, p. 35, ♂. *New synonymy.*

Female.—Length, 12 mm. Color, very similar to light forms of *T. leucostoma* (Kby.). Body mostly black, with the following parts creamy white: mandibles except tip, labrum, clypeus, a small spot on cheeks at base of eyes, an obscure spot on upper inner margin of eyes, posterior margin of pronotum, tegulæ and meta-episternum, sometimes a horizontal mark on posterior portion of meso-episternum just above pectus, and rarely an obscure vertical mark just below tegulæ. Pectus either black, or entirely rufous, or black with rufous bars. Abdomen black with a variable amount of the venter at the base creamy rufous or brownish rufous. Legs yellowish rufous with apical half or two-thirds of hind tibiæ and all hind tarsi black.

Allotype.— ♀, Cedar Bog, Urbana, Ohio, June 9, 1929 (C. H. Kennedy).

The following specimens of this species have been examined: 23 ♂♂ and ♀♀, same data as allotype; 4 ♂♂, 3 ♀♀, Algonquin, Ill., (Nason); 2 ♀♀, Northern Illinois; 1 ♂, Orono, Me., June 14, 1913. The rufous on the dorsum of the abdomen of the male varies considerably, from having the first three segments beyond the basal plates entirely rufous, to having them rufous at the base with an apical black band. The type of *T. rubricosa* is from Algonquin, Ill., and is a specimen with the first three terga rufous. There is a possibility that this is a southern color form of *T. leucostoma* (Kby.).

Tenthredella tricolor (Norton).

Allantus tricolor Norton, Boston Jour. Nat. Hist., Vol. VII, 1860, p. 247, ♀.
Tenthredo cressonii Kirby, List Hymen. British Mus., Vol. I, 1882, p. 315, ♀. *New synonymy.*
Tenthredella rohweri Smulyan, Can. Ent., Vol. XLVII, No. 10, Oct., 1915, p. 323. N. n. for *tricolor* Nort.
Tenthredella tricolor Smulyan, Proc. Boston Soc. Nat. Hist., Vol. 36, No. 6, Jan., 1923, p. 441, ♀.

A large series of specimens from various localities in central and northern Canada shows this species to be one of the most variable in the genus. The abdomen varies from an almost entirely rufous condition to being entirely black; similarly the amount of rufous on the legs is extremely variable. Kirby's species *cressonii* is apparently the most rufous form described, having very little black at the base of the abdomen. It might be considered by some as a variety of *tricolor*. Norton's original description is of the form with the two basal segments entirely black, which is the commonest color pattern encountered. A continuous series of variations has been studied from this typical variety to the entirely black form, described by Norton as *Tenthredo concessus*. The male of this species, heretofore undescribed, has been definitely associated with the female.

Male.—Length, 9 mm. Structure similar to that of female. Color: head black with clypeus, labrum, outer lateral faces of mandibles, apical segments of palpi, and sometimes a spot variable in size on the postgenæ adjacent to the eye, chalky white; thorax, excluding legs and wings, entirely black, except usually a spot on the meta-episternum which is yellowish white. Abdomen bright rufous, with basal plates, more or less of dorsum of first and last segments, hypopygium and claspers, black. Legs mostly rufous and black; coxæ black, except anterior and sometimes lateral chalky spots on the front coxæ and an indistinct rufous area on the lateral aspect of the hind coxæ; trochanters black; femora with posterior side black, front femora with anterior side yellowish and middle and hind femora with anterior side rufous; front and middle tibiæ and tarsi rufous, with a more or less distinct black line above; hind tibiæ either entirely black or black with basal third reddish black; hind tarsi black with apical segment rufous. Wings with costa, subcosta and stigma blackish brown; veins dark brown; membrane hyaline, very slightly tawny infuscate especially below stigma. Two specimens believed to belong to this species have the hind femora and most of the middle ones entirely black.

Allotype.—♂, Gull Lake, Alberta, June 18, 1929 (E. H. Strickland).

The female of typical *tricolor* and its slighter variations is easily separated from species with a rufous-banded abdomen in lacking yellow marks on the orbits, collar, tegulæ and dorsum of the thorax, and in having a rufous area on the genæ and *rufous* instead of *yellow* combined with black on the legs.

The following specimens of the typical form, or variations so slight that they may be considered within the typical sense, have been examined: Alberta, 8 ♂♂, 10 ♀♀, Edmonton and Gull Lake, June 8 to July 1, 1929 (E. H. Strickland); 2 ♀♀, Edmonton, June 5 and 6, 1924 (O. Bryant); Saskatchewan, 1 ♀, Fort a la Corne, July 17, 1925 (Kenneth M. King); Manitoba, 1 ♂, Aweme, June 29; 3 ♀♀, Aweme, June 17; 1 ♀, Birtle, June 21; 1 ♀, Treesbank, July 6, all 1926 (R. D. Bird); Montana, 1 ♀, Gallatin Mts., July 7, 1914; 1 ♀, Bozeman, June 30, 1916; South Dakota, 3 ♀♀, Spearfish, July 16 and 26, 1923 and 1924, (H. C. Severin).

Tenthredella tricolor var. **concessus** (Norton).

Tenthredo concessus Norton, Trans. Amer. Ent. Soc., Vol. II, 1869, p. 238, ♀.
Tenthredo uniformis Kirby, List Hymen. British Mus., Vol. I, 1882, p. 317, ♀. *New synonymy.*

This variety, in which the body is almost entirely black, is most easily confused with *T. melanosoma* (Harrington), but is easily separated from it and its close allies by having *rufous* instead of *yellow* on the anterior face of the front legs. The amount of rufous on these parts varies considerably, Kirby's description of *uniformis* representing the most extensive development of rufous and Norton's description of *concessus* the least extensive. Specimens showing the following distribution have been studied: Maine, 1 ♀, Orono, June 23, 1913; Michigan, 1 ♀, Cheboygan County, Douglas Lake, June 25, 1925 (C. F. Byers); Alberta, 1 ♀, Edmonton, July 1, 1912 and 3 ♀♀, Gull Lake, June 20 to 28, 1929 (E. H. Strickland); and Manitoba, 2 ♀♀, June 29 and July 10, 1926 (R. D. Bird).

Tenthredella tricolor var. **savanna** new variety.

Female.—Similar in size and structure to the typical *tricolor*. In color transitional between the typical form, which has the abdomen rufous with the two basal segments more or less black, and *tricolor* var. *concessus* which has the abdomen entirely black. Body black with the following parts yellow: mandibles except tip, labrum and clypeus, a minute spot on inner, upper margin of eye, cenchri, sometimes a spot on

meta-episternum and a small spot on ventro-lateral margin of basal plates; with the following parts rufous: lower portion of genæ and first antennal segment in most cases; front legs beyond coxæ except more or less of posterior aspect of femora, middle tibiæ and tarsi, apical half to entire anterior aspect and sometimes an apical spot on posterior aspect of middle femora, more or less of base of posterior tibiæ, and posterior tarsal segments except sometimes at apex; and third, or third and fourth or third, fourth and part of second, abdominal segments.

Holotype.— ♀, Gull Lake, Alberta, June 14, 1929 (E. H. Strickland).

Paratypes.—7 ♀♀, Gull Lake, Alta., June 8 to 28, 1929 (E. H. Strickland); 1 ♀, Edmonton, Alta., June 2, 1924 (O. Bryant); and 1 ♀, Spearfish, S. D., July 26, 1924 (H. C. Severin). Deposited with the holotype and in the Canadian National Museum, the University of Alberta, and the South Dakota State College.

Tenthredella stricklandi new species.

Female.—Length, 9 to 10 mm. General color, greenish or yellowish white with black maculations as follows: antennæ except ventral half beyond two-thirds the length of first segment, and lateral and part of mesal surfaces of scape, which are greenish white; a spot surrounding ocelli, extending between raised margins of antennal sockets, including anterior half of postocellar area and extending laterally one-half or less the distance between the antennal furrows and the eyes; vertical furrows, a spot on postero-lateral margin of eye near apex, a small spot opposite eyes on the posterior margin of head, and the entire posterior aspect of the head; greater part of mesonotum except broad, complete *V*-spot on anterior lobe, a pair of arrow-shaped marks on lateral lobes, scutellum entirely, post-tergite and more or less of sutures of posterior region, which are greenish white; lateral lobes of metanotum; entire pectus, a broad line on the ventral margin of the meso-epimeron and sutures of meta-pleuræ; and the sternites of the abdomen and the sheath. Legs, including coxæ, greenish white with a moderate black line down the posterior side of the femora, tibiæ and tarsi, more or less evanescent at the base of femora and usually thin and interrupted on all the tibiæ. Wings hyaline; costa, stigma and base of anal veins green or greenish white, remainder of veins shining black or brownish black. In older, pinned specimens the dorsum of the abdomen, green in life, discolors, and becomes a pale brownish white.

Mesal margins of antennal sockets strongly produced and raised; fourth antennal segment only two-thirds length of third; dorsum of head polished, with few, minute punctures, lateral lobes with sparser punctures; scutellum only feebly convex, shining, scarcely punctate; post-tergite flat with a slight median carina, with separate, fairly large punctures around the posterior margins; tarsal claws cleft, the inner ray slightly the shorter.

Male.—Length, 8 to 9 mm. Color, greenish or yellowish white, with black markings essentially as in female, with the following exceptions: scape, pectus and entire abdomen greenish white; black markings on head behind eyes absent; black line on legs slightly stronger and wider. Structure as in female.

Holotype.— ♀, Waterton, Alberta, July 13, 1923 (E. H. Strickland).

Allotype.— ♂, same data, but July 12.

Paratypes.—1 ♂, 6 ♀ ♀, same data as holotype and allotype; 3 ♂ ♂, 7 ♀ ♀, Gull Lake, Alta., June 14 to 28, 1929 (E. H. Strickland); 1 ♀, Edmonton, Alta., June 30, 1923 (E. H. Strickland); 1 ♀, Moscow, Idaho, June 18, 1895 (J. M. Aldrich); 2 ♀ ♀, Ground Hog Basin, Big Bend Country, Selkirk Mts., B. C., July 24, 1905 (J. C. Bradley). Deposited with the holotype, and in the collections of the Canadian National Museum, the University of Alberta, the University of Illinois, and the author.

This species is most closely related to *T. rhammisia* (MacG.), but is smaller and differs in the female in having the pectus and venter of the abdomen black, and in the male in having the flagellum of the antennæ greenish beneath. In color both *T. stricklandi* and *T. rhammisia* resemble several species of *Rhogogaster*, for which they have often been mistaken in collections.

Tenthredella rhammisia (MacGillivray).

Tenthredo rhammisia MacGillivray, Univ. Ill. Bull., Vol. XX, No. 50, Aug. 13, 1923, p. 33, ♀.

Male.—Length, 10 to 11 mm. Color in life virid light green with black markings. In mounted specimens the green changes to yellowish or greenish white. Color distribution and markings exactly as in female. Antennæ in both sexes with basal segment entirely yellowish or mostly black with yellowish lines or spots; flagellum normally entirely black, sometimes suffused with fuscous on ventral side towards tip. Black line down posterior aspect of legs slightly stronger in male. Structure similar in both sexes.

Allotype.— ♂, Vancouver, British Columbia, July 1, 1929 (H. H. Ross).

Specimens of this species have been examined from the following localities: ♀ (holotype), Sea Side, Ore., August 15, 1914 (L. G. Gentner); 1 ♂, Alsea, June 4, 1922 (A. L. Lovett) and 2 ♀ ♀, Corvallis, June, Ore.; 1 ♀, Olympia, May 27, 1894, and 1 ♀, Mt. Steel, Jefferson County, July 17, 1919 (F. M.

Gaige), Wash., 2 ♂♂, same data as allotype, and 1 ♂, Agassiz, May 18, 1926 (H. H. Ross), B. C.

This species is closely related to *T. stricklandi* Ross, under which the differentiating characters are given. It differs markedly from that species in having the two sexes concolorous. It has the mesal margins of the antennal sockets moderately raised, and the scutellum and post-tergite as in *stricklandi*.

Tenthredella perplexus (MacGillivray).

Tenthredo perplexus MacGillivray, Jour. N. Y. Ent. Soc., Vol. V, No. 3, Sept., 1897, p. 106, ♀.
Tenthredo commata Konow, Zeits. Hymen. Dipt., Vol. 8, Heft 1, Jan. 1, 1908, p. 90, ♀. *New synonymy.*

The description of Konow's specimen from Alaska agrees in every particular with MacGillivray's type specimen from Washington and with other specimens from Oregon.

Genus **Macrophya** Dahlbom.

Macrophya fumator Norton.

Macrophya fumator Norton, Trans. Amer. Ent. Soc., Vol. I, 1867, p. 279, ♀.
Macrophya jugosa Cresson, *ibid*, Vol. VIII, 1880, p. 18, ♂. *New synonymy.*
Macrophya bicolorata Cresson, *ibid*, ♀. *New synonymy.*
Synairema pacifica Provancher, Addit. Vol. II, Faun. Ent., Hymen., 1889, p. 15, ♀. *New synonymy.*
Perineura kincaidia MacGillivray, Can. Ent., Vol. XXVII, No. 1, Jan., 1895, p. 7, ♀. *New synonymy.*
Macrophya obrussa MacGillivray, Univ. Ill. Bull., Vol. 20, No. 50, Aug. 13, 1923, p. 22, ♂. *New synonymy.*

The holotype of *P. kincaidia* MacGillivray is a specimen identical in every respect with the typical form of *fumator*. Specimens identified by Dr. MacGillivray as *S. pacifica* Provancher are typical of the form *bicolorata* Cresson, lacking the white spot on the hind tibiæ. The male of this species has the abdomen always black, not varying as in the female. In the male, also, the white spot on the apices of the hind tibiæ varies considerably in size, but no specimens have been examined in which it was entirely absent. On the humid belt of the Pacific Coast a melanic form of the female appears in which the abdomen is entirely black, viz., var. *maura* Cresson. The typical form occurs in the same locality but no intergrades between the two have been seen. Specimens from this region have the white spot on the hind tibiæ very large, often half the length of the tibiæ. In more arid regions of higher altitudes, such as Idaho and western Colorado, only the females with a

rufous abdomen are taken, and in these the white spot on the hind tibiæ is extremely variable, being found on different specimens in every state between and including being entirely absent to being a third or a half the length of the tibiæ. The form in which the spot is absent was given the name *bicolorata* by Cresson, but since both this and the typical form may be taken in the same locality it does not seem advisable to the author to consider such a slight and variable difference in color under a separate varietal name.

The following specimens of this species have been examined: British Columbia, 1 ♀, Rock Cr., June 5, 1926 (P. N. Vroom); 1 ♀, Agassiz, May 29, 1927 (L. Black); 2 ♂♂, 1 ♀, Vernon, May and June (Buckell and Cutler); California, 1 ♀, Woodside, April 25, 1906 (J. M. Aldrich); 2 ♀♀, Berkeley, May 5, 1915 (M. C. VanDuzee); 1 ♂, Portola, June 5, 1915 (M. C. VanDuzee); Colorado, 1 ♀, "Col."; 1 ♀, Clear Cr., June 27, 1906 (Oslar); Idaho, many ♂♂, ♀♀, Juliaetta, Bellevue, Lake Waha, Moscow and Reuben, May and June; Oregon, ♂♂, ♀♀, Corvallis, May and June (H. A. Scullen); Washington, ♂♂, ♀♀, Olympia, May and June (Trevor Kincaid); 1 ♀, Friday Harbor, May 30, 1906 (J. M. Aldrich).

Macrophya fumator var. **maura** Cresson.

Macrophya maura Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 18, ♀.

This, as explained above, is a melanic variety of the female, the male being black in all forms of the species. The same climatic factors which apparently cause the abdomen to be black, seem at the same time to produce a very large apical white spot on the hind tibiæ, it being usually half the length of the tibiæ. The following specimens have been examined: 2 ♀♀, Agassiz, B. C., May 29, 1927 (L. Black) and May 16, 1927 (H. H. Ross); 3 ♀♀, Corvallis, Ore., 1900; 2 ♀♀, Corvallis, Ore., June 1, 1927 (H. A. Scullen); 1 ♀, Olympia, Wash., (Trevor Kincaid).

Macrophya subviolacea Cresson.

? Macrophya pumilus Norton, Trans. Amer. Ent. Soc., Vol. II, 1867, p. 272, ♂.
Macrophya subviolacea Cresson, *ibid*, Vol. VIII, 1880, p. 18, ♀.

A series of eight females of this species in the A. D. MacGillivray Collection, bearing the data "Berkeley, Calif., May 15, 1915 (M. C. VanDuzee)," have been studied. In this species

the rugose front below the ocelli, the large, well-separated punctures on the scutellum, and the highly polished surfaces of the mesonotum are very typical of *M. fumator* Nort. The color of the wings and the body is exactly as in *M. fumator* var. *maura* Cress., with the exception of the hind tibiæ which are entirely black without a trace of the apical white spot. In *M. fumator* var. *maura* there is a marked tendency for this spot to increase rather than decrease in size, and for this reason *subviolacea* is considered a distinct species closely related to *fumator*.

I have not seen any specimens of Norton's species *pumilus*, but his description of it agrees well with *subviolacea*, the differences in color of legs, wings, labrum and clypeus being the same as the differences between the male and female of *fumator*. If the study of a large series of specimens indicates that this surmise is correct, Cresson's name *subviolacea* will have to be considered a synonym.

Macrophya oregona Cresson.

Macrophya oregona Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 19, ♀.
Macrophya obaerata MacGillivray, Univ. Ill. Bull., Vol. 20, No. 50, Aug. 13, 1923, p. 21, ♀. *New synonymy.*

The specimen described by Dr. MacGillivray is structurally identical with typical *M. oregona* Cresson, but differs slightly in color in having a small *V*-spot on the anterior lobe of the mesonotum and a spot on the dorso-apical portion of the hind femora, white. The four specimens at hand of this species studied by the author show four sequential steps from the condition in which the hind femora are entirely black to that in which they are almost entirely ringed with white at the apex, and one has the *V*-spot, absent in two, even larger than has the type of *obaerata*. Since this variation occurs in so few specimens it is natural to suppose that the species is consistently variable in these characters, and since, furthermore, the variation occurs in specimens from relatively close geographical points, it seems scarcely advisable to retain *obaerata* as a variety. The data associated with the typical specimens studied are as follows: 1 ♀, Olympia, Wash. (Trevor Kincaid); 1 ♀, Corvallis, Ore. (Fitch); 1 ♀, Agassiz, B. C., July 6, 1927 (H. H. Ross); 1 ♀, Vancouver, B. C., June 26, 1929 (H. H. Ross).

No males corresponding to this phase have been seen, but three have been taken which are intermediate between this and the following darker variety. These have the scutellum partly white and one has one segment of one antenna almost entirely white. They were taken with the female from Vancouver. It may be that the males never do have as rich a white ornamentation as the females.

Macrophya oregona var. **dukiæ** new variety.

Male.—Length, 7 to 8 mm. Color of body entirely black except the following parts which are white: labrum, apical half or two-thirds of clypeus, lateral aspect of mandibles, and most of the ventral aspect of the abdomen. Antennæ entirely black. Front and middle coxæ with basal third black, apices white, hind coxæ black with mesal half of ventral aspect and an elongate spot near base along the dorso-lateral angle, white; trochanters white; front and middle femora, tibiæ and tarsi with anterior face white, posterior face black, tarsi sometimes with a pale, ringed appearance; hind femora black with more or less of the ventral edge white towards base; hind tibiæ black with an elongate-oval white spot varying from one-sixth to one-quarter the length of the tibiæ, near the apex on the dorsal side; hind tarsi black, the apical two segments shading to light brown. Wings hyaline at base, apical half very lightly brown infuscate.

Structure similar to the typical *oregona* female.

Female.—Size and structure as in the typical form. Differs in color in having the antennæ and scutellum *entirely black*. The *V*-spot and the hind femora are also entirely black, and the middle femora have only a little white at each end.

Holotype.— ♂, Vancouver, British Columbia, July 1, 1929 (H. H. Ross).

Allotype.— ♀, same data as holotype.

Paratypes.—7 ♂ ♂, same data as holotype, and 1 ♀, Muir Woods, Marin County, Calif., May 19, 1915 (M. C. VanDuzee).

Due to its black coloring, this variety is most likely to be confused with *M. fumator* var. *maura* Cress. and *M. subviolacea* Cress., but may be separated from them by the closely punctured and rough scutellum and the white lateral spot on the hind coxæ.

This variety is interesting in that it is the first case on record of a nearctic species of *Macrophya* in which the antennæ may vary in color from almost entirely white to entirely black.

Macrophya fascialis Norton.

Macrophya fascialis Norton, Trans. Amer. Ent. Soc., Vol. II, 1869, p. 276, ♀.

A large series of the typical form of this species has been collected at Oakwood, Ill., June 15 to July 4, 1930 (H. H. Ross). The male is similar in color to the female.

Macrophya fascialis var. **puella** new variety.

Female.—Identical in size and structure with typical *fascialis*. Differs in color as follows: cheeks, orbits, meso- and metapleuræ and basal plates entirely black instead of white, some specimens with minute white spots on these parts, but never suggestive of the extent to which they are present in the typical form. Abdomen, as in the latter, either entirely rufous beyond the first segment or with the apical two or three segments blackish or black. Color of legs essentially as in typical *fascialis*.

Male.—Similar to female, but with the more or less sanguineous red of the female replaced by a lighter orange-red. *V*-spot on anterior lobe almost absent.

Holotype.— ♀, Douglas Lake, Michigan, July, 1929 (C. H. Kennedy).

Allotype.— ♂, same data.

Paratypes.—13 ♀ ♀, same data.

This variety is very similar in structure and color to *M. varius* (Nort.), from which it is easily distinguished by the color of the hind femora as given in the key which follows the treatment of these species.

Macrophya varius (Norton).

Allantus varius Norton, Boston Jour. Nat. Hist., Vol. VII, 1860, p. 240, ♀.

I have not yet seen typical specimens of this species, but in his descriptions of it, Norton notes, among others, the following color characters: scutellum, post-tergite and metascutellum white; legs yellowish rufous, no mention being made of black on the coxæ; basal plates and abdomen rufous.

Certain color phases of what appear to be this species have been studied and due to the possibility that more than one species might be involved, it has seemed advisable to give varietal names to the more distinct of these. Males of this species have the basal two segments of the antennæ either yellowish rufous or black without correlation with other color

characters. Although only relatively few records are available, there seems to be indicated a geographical segregation of these varieties, but until more material is examined it will be unsound to make any general statements in this respect. The relations of the various varietal forms may be seen in the accompanying key.

Macrophya varius var. **festana** new variety.

Female.—Similar to the description of *varius*, but differing in the following color characters: only the basal segment of antennæ rufous; *V*-spot and scutellum white, but post-tergite and metascutellum rufous or rufous with anterior margin black; abdomen rufous with the four apical terga and sawguides *black*. Hind coxæ, metapleuræ, basal plates and base of abdomen rufous, slightly lined with black at base; femora rufous; front and middle tibiæ with posterior aspect black; hind tibiæ rufous, apex blackish and with a dorsal white spot; hind coxæ with lateral white spot; hind basitarsus black with a white ring or dot at apex, remaining hind tarsi white with black ring at apex.

Holotype.— ♀, Algonquin, Illinois (Wm. Nason).

Paratypes.—1 ♀, Northern Illinois (Coll'n of G. C. Davis); 1 ♀, Douglas Lake, Mich., July (C. H. Kennedy); 1 ♀, Aweme, Man., July 18, 1913 (E. Criddle).

This variety possesses the peculiar combination of rufous coxæ, basal plates, etc., with black hind basitarsi and apical segments of the abdomen.

Macrophya varius var. **eurythmia** Norton.

Macrophya eurythmia Norton, Trans. Amer. Ent. Soc., Vol. I, 1867, p. 276, ♀, ♂.
Macrophya nidonea MacGillivray, Can. Ent., Vol. XXVII, No. 3, Mar., 1895, p. 77, ♂. *New synonymy.*

The following specimens have been studied: 1 ♀, Edmonton, Alta., July 9, 1929 (E. H. Strickland); 4 ♀♀, Gull Lake, Alta., June 8 to 26, 1929 (E. H. Strickland); 1 ♀, Aweme, Man., June 24, 1912 (E. Criddle); 1 ♀, Aweme, Man., July 8, 1913 (N. Criddle); 1 ♂, 1 ♀, Montreal, P. Q., June 14 to 19, 1925 (J. W. Buckle); 1 ♂, 3 ♀♀, Orono, Me., July 7 to 22, 1913; 1 ♀, Mt. Washington, N. H.; 1 ♂, 1 ♀, Adirondack Mts., Axton, N. Y., June 12-22, 1901 (A. D. MacGillivray); 1 ♂, Karner, N. Y., June 5, 1906; 1 ♂, Nassau, N. Y., May 30, 1908. The female specimens from Maine, New York and Quebec differ in having the abdomen beyond the second segment

entirely chestnut in color, but in all other respects agree with Norton's description of *eurythmia*, and so I am considering them the extreme light form of the variety. The specimens from Alberta have the bases of the antennæ entirely black, and are midway between the typical form of the variety and var. *nordicola*. *M. nidonea* MacG. is undoubtedly a male of *varius* and agrees with the color characteristics of this variety.

Macrophya varius var. **nordicola** new variety.

Female.—Similar in size and structure to typical *varius*. Differs in color in being almost entirely black. Body, including abdomen, black, with the following parts white: base of mandibles, clypeus, labrum, two spots on posterior margin of head behind ocelli, apical four antennal segments except extreme tip of ninth, posterior margin of collar, *V*-spot, scutellum, spot at apex of post-tergite, metascutellum, apical margins of abdominal sternites and postero-mesal margins of ventral portion of tergites. Coxæ black with apices and lateral and mesal margins white, posterior pair with a large lateral white spot; trochanters white; remainder of front and middle legs with anterior aspect white and yellowish rufous, posterior aspect black or blackish rufous; posterior femora with basal third or fourth whitish, extreme apex ringed with black, remainder deep rufous, in one specimen with the dorsal half, both anterior and posterior, black, shading ventrally to a blackish rufous; hind tibiæ black with middle half rufescent; hind tarsi all with a narrow apical black ring, and with basal half of basitarsus black, otherwise white. Abdominal tergum with a faint suggestion of fuscous on some parts of the meson.

Male.—Similar to female, but with the second and third tergites with the mesal central portion blackish fuscous, and with more white and less black on the front and middle legs.

Holotype.— ♀, Gull Lake, Alberta, June 24, 1929 (E. H. Strickland).

Allotype.— ♂, same data as holotype. Deposited in the Canadian National Museum.

Paratypes.—1 ♀ and 1 ♂, same locality, collector and year, June 20 and 18. In the collections of the University of Alberta and the author.

This variety is a step beyond *varius* var. *eurythmia* in the replacing of red by black, and is apt to be confused with *trisyllaba* var. *sinannula*, but is at once separated from that form by the rufous color of the legs and the large amount of white on the anterior aspect of the front and middle legs.

Macrophya trisyllabus (Norton).

Allantus trisyllabus Norton, Boston Jour. Nat. Hist., Vol. VII, 1860, p. 238, ♀.
Macrophya trisyllabus Norton, Trans. Amer. Ent. Soc., Vol. I, 1867, p. 274, ♂, ♀.

A large series of specimens shows that this species varies considerably, especially in the female, in the following color characters: the transverse white lines on the apical margins of the tergites, the distinctness of the *V*-spot on the anterior lobe of the mesonotum, the amount of white on the abdominal sterna, and the amount of white on the ventral margin of the hind femora. The typical form has all the markings well developed. In more southern localities these different markings vary in development more or less independently of each other, so that no satisfactory grouping can be made using any single one as a basis. The transverse white markings on the apical margin of the tergites when strongly developed are enlarged on the meson to form a series of triangular marks with the apices pointing basad; when more weakly developed the white first disappears on each side of this spot and the spot itself may be reduced to two small transverse spots, one on each side of the meson.

This species is most closely related to *M. zonalis* Norton, and may be confused with it, but in *zonalis* the white on the apices of the abdominal terga forms only a narrow line, not enlarged on the meson, but instead reduced or interrupted. The color of the hind coxæ can not be used to separate these two species, because although *zonalis* usually has the ventral face of the hind coxæ white and *trisyllabus* usually has it black, rare cases have been observed in which the opposite was the case. *Trisyllabus*, however, has never been observed with any trace of white on the mesopleuræ, while *zonalis* has always a white mark on the angle of the meso-episternum immediately beneath the tegulæ, and usually a large white spot or area below this.

About 150 specimens of the typical, or near typical, form of *trisyllabus* have been examined, representing the following distribution: Illinois, Algonquin, Savanna and Oakwood, June and July; Massachusetts, Chicopee, July 27, 1881, and Wellesley; Michigan, Douglas Lake, July (C. H. Kennedy); New Hampshire, Mt. Washington; New York, Ithaca, Axton, Jamaica, Wells, Elm Lake, Newport, Poestenkill, Chapel Pond,

Johnstown, Poughkeepsie, Adirondack and McLean Bogs, Tompkins County, June to August; Ohio, Cedar Bog, Urbana (C. H. Kennedy), Salineville and Hocking County, June; Pennsylvania, Philadelphia and Jeannette, June; Rhode Island, Kingston, August 8, 1907; Manitoba, Aweme, June (E. Criddle); Quebec, St. John's County, July (Chagnon).

Macrophya trisyllabus var. **sinannula** new variety.

Female.—In structure similar to the typical form of *trisyllabus*, but a trifle smaller in size. Differs in color in lacking the *V*-spot on the anterior lobe of the mesonotum and lacking the white transverse bands on the apical margins of the abdominal terga. The pronotum may also be entirely black. The venter of the abdomen, as in the typical form, may be entirely black or with some white transverse markings at the apices of the segments.

Male.—Similar to female, except that, as also in the typical form, the venter of the abdomen is well marked with white.

Holotype.— ♀, Edmonton, Alberta, June 16, 1926 (E. H. Strickland).

Allotype.— ♂, same data as holotype.

Paratypes.—7 ♂♂, 5 ♀♀, Gull Lake, Alta., June 8 to 26, 1929 (E. H. Strickland); 1 ♂, 1 ♀, Edmonton, Alta., June 16, 1926 (E. H. Strickland); 1 ♀, Edmonton, Alta., June 13, 1929 (E. H. Strickland); 4 ♀♀, Aweme, Man., June 25 to July 8, 1913 (E. Criddle); 1 ♂, 1 ♀, Algonquin, Ill. (Nason); 1 ♀, Oakwood, Ill., June 22, 1930 (H. H. Ross); 2 ♀♀, Orono, Me., July 11 to 15, 1913; 3 ♂♂, Mackinac Island, Mich., July, (C. H. Kennedy); 1 ♂, 3 ♀♀, Ithaca, N. Y., July 2 to August 20, 1918; 1 ♀, Cranberry Cr., N. Y., June 22, 1914; 1 ♀, Old Forge, N. Y., July 13, 1905.

The variety as limited in the above description seems to be the form of the species occurring in the more northern localities of the continent. It is given a varietal name because of its apparent geographical significance and because in determinations it has been confused with *M. niger* Nort. and *M. varius* var. *nordicola* Ross, from which it is readily separated by characters given in the following key.

The nearctic species of **Macrophya** in which the antennae have a group of white apical segments may be separated in the female sex by the key given below.

1. Dorsum of abdomen entirely black except sometimes for a slight fuscous area in middle, or black with white marks 2
   Abdomen with at least one or two tergites entirely rufous 7
2. Scutellum black ..... **niger** Norton
   Scutellum entirely or partly white 3
3. Hind femora with at least ventro-lateral portions rufous, dorsal portions sometimes black; middle portion of tibiae rufous or blackish rufous, **varius** var. **nordicola** Ross
   Hind femora and tibiae without rufous, being a combination of black and white 4
4. Hind tibiae with a large white spot on the dorso-apical region, **oregona** Cresson
   Hind tibiae entirely black 5
5. Extreme dorsal angle of meso-episternum and a spot below it on pleurae, white, the two spots sometimes coalescing, the lower one sometimes indistinct; annulations on apical margin of abdominal terga, if present, narrow, reduced or interrupted on meson ..... **zonalis** Norton
   Pleurae entirely black; white annulations on terga, if present, usually enlarged on meson to produce triangular marks 6
6. Anterior lobe without a white V-spot; dorsum of abdomen entirely black ..... **trisyllabus** var. **sinannula** Ross
   Anterior lobe with a V-spot; some tergites of abdomen usually with a transverse white line or transverse dots on apical margin, rarely entirely black ..... **trisyllabus** (Norton)
7. Meso-episternum with a large white spot, occupying about half its area, **fascialis** Norton
   Meso-episternum black, at most with a minute pale spot 8
8. Hind femora with apical half of posterior aspect black; entire basal half white, apical half usually entirely black except for extreme apex, which is always ringed with pale; anterior face of hind femora sometimes pale ..... **fascialis** var. **puella** Ross
   Hind femora without black on posterior face; usually entirely rufous or yellowish rufous in color, paler towards base; sometimes with a small amount of black which is in the form of a very narrow ring around extreme apex 9
9. Coxae rufous 10
   Coxae black at base ..... **varius** var. **eurythmia** Norton
10. Abdomen entirely rufous ..... **varius** (Norton)
    Abdomen with apical three or more segments black, base rufous, **varius** var. **festana** Ross

CONTRIBUTION TO THE BIOLOGY OF THE HALIPLIDÆ (COLEOPTERA).*

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The literature contains several scattered references to the biology of Haliplidæ. Except for the work of Matheson (1912, 156–193) and Wilson (1923, 231–345) on a few species, no extensive study of these beetles in America has been made. In connection with some life history (Hickman, 1930, 399–424) and experimental work (Hickman, in press) on haliplids, data were accumulated which seem worthy of publication. The beetles studied were found in the vicinity of Ann Arbor and of Douglas Lake, Michigan. In order to work out the life histories, it was necessary to develop culture methods by which the development could be carried through from the egg to imago. Such methods were discovered and the complete life cycles of all species known in Michigan were worked out.

The author wishes to express his indebtedness to Professor Paul S. Welch, under whose direction this study was made; to Professor George R. LaRue, director of the University of Michigan Biological Station, for the courtesies extended while working in the Douglas Lake region; and to various other persons for materials and assistance.

REARING METHODS.

The problem was first attacked by trying to keep the adults in the laboratory until egg laying time. After considerable experimentation, methods were found by means of which it was possible to maintain these insects the year around. Beetles collected in the field were separated, according to species, into finger bowls containing water, but not more than a dozen individuals were put in one bowl. Cistern water was used for the cultures of all the stages, although from experiments it appeared to have no particular advantage over tap, pond or distilled water. A little muck was placed in the bottom of

*Contribution from the Zoological Laboratory and the Biological Station of the University of Michigan.

the bowls in order that the beetles might hide in it when disturbed. Branches of *Elodea*, *Chara*, or *Ceratophyllum* were also introduced so that they could have a place on which to oviposit. The plants mentioned were never changed during the winter. Water was added about every month to replace that which had evaporated. During the summer, changes were made whenever the water became foul, at times as often as once a week. Temperatures up to about 75° F. had no detrimental effects, winter or summer, but much higher temperatures were destructive. Food was furnished not oftener than once a month during the winter since the beetles require little at this season, and the food will remain in good condition for a long time. During the summer, these conditions are reversed. The beetles require more food because they are more active and the food will soon deteriorate in warm water. As often as every other day a little food was added. The kinds of food will be discussed under a later topic.

When eggs appeared, they generally were removed to separate finger bowls which contained water. Removing the eggs from the water did not seem to do any damage. The temperature was maintained at about 70° F. No particular attention was given them until hatching time. Very few eggs failed to hatch.

The larvæ were very easy to rear in the laboratory when a few essential factors remained about constant, such as food, temperature, and condition of the water. They were separated into stender dishes which contained water to a depth of about one inch. Each larva was isolated in a dish. During the warm days of summer when the temperature was much above 75° F., the water was changed daily and all unconsumed food removed. The water was either removed by means of a large pipette or the larvæ were removed to new cultures by use of forceps. In order that the condition of the cultures dishes could be observed easily, they were arranged on a shelf one row deep. Covers were placed on the dishes to check the evaporation of the water. They were never exposed to the direct sunlight.

The pupa was the most difficult stage to obtain because the larva will not pupate unless conditions are right. Instead, it would remain as larva or would die. Nevertheless, the pupæ of all the different species were secured. When the larvæ

had reached the third instar they were transferred to a smaller stender dish containing a little water and food. A branch of water plant was so arranged that it extended over the top of the dish in order that the larvæ could crawl out to pupate. This small dish was placed inside of a larger stender dish which contained a small amount of earth. This earth had been taken from the shore of the lake in the vicinity of the place where they naturally would pupate. Before they would enter this earth the latter had to have the right moisture content. This seems to be the most important factor. If it was too wet or too dry they would not construct the pupa chamber. It was found that if the earth was just damp enough to hold together, the larvæ would pupate. A few drops of water were added from time to time to prevent undue drying. Fungus growths had to be watched for and elimintaed. They were largely avoided at the outset by moistening rather large quantities of this shore material, allowing it to stand for a few days before using, and selecting those samples which showed no fungus growth.

Biology of the Imago.

Although the general environment of these beetles has been known for a long time, yet, it seems proper to analyze the habitats a little more in detail. Generally speaking, adult haliplids are found in standing water or slow streams where the proper food is found. They are not adapted to swift currents, as they can not swim fast enough to make any headway. The habitats might be enumerated as follows: pools; deep, slow moving streams, protected places along rivers; roadside pools; ponds; and protected places in lakes. In fact, they were always found where their food occurred, and since all of the different kinds of food are not found in all the places mentioned above, there would necessarily be a limitation as to which species might be present. Within the usual limits, such factors as pH, dissolved oxygen, and transparency seem to have no effect on the distribution. *H. immaculicollis* Harr. was more generally found in the smaller ponds and pools. *H. cribrarius* Lec. occurred only in the slightly deeper water of lakes among the *Chara* and *Nitella* beds, and was the hardest to collect for this reason. Some were taken under 6 feet of water, and they might have been taken in still deeper water had the special

effort been made. *H. triopsis* Say is another lake form found among the *Elodea* and *Chara*, but was taken often near the shore in shallower water. *Peltodytes sexmaculatus* Rbts., and *P. edentulus* Lec. were cosmopolitan in distribution as they were found in all the above listed places. In the vicinity of Ann Arbor, *P. lengi* Rbts. is restricted to the Huron River and its branches, although no reason can be given for this selected habitat.

Matheson (1912, pp. 181–182) and Leng (1913, p. 33) have discussed the structural adaptations of these beetles for aquatic life and further comment seems unnecessary except to mention another function for the posterior coxal plates. It has been already stated by many investigators that these plates retain an air store but experiments discussed in another paper (Hickman, in press) showed that the expanded coxal plates enable the beetle to hold a bubble of air for the purpose of tipping the apex of the abdomen through the surface film.

Not much can be added to what is already known concerning the locomotion of these beetles. They are poor swimmers although the tarsi of the second and third legs are provided with a fringe of long setæ. That they swim with ambulatory movements was definitely proven by means of motion pictures. They spend most of their time while in water walking over the vegetation and swimming short distances. On land, they are good walkers and can run with some speed. They can fly as shown by the fact that they have been taken at electric lights (Knaus, 1899, p. 110). In the laboratory, they very often will leave the cultures and fly to a desk light.

Several investigators have observed that the beetles of this family are not carnivorous as was generally thought, but are herbivorous. Matheson (1912, p. 182) was the first to observe that they feed upon plants. He states "In my aquarium *H. ruficollis*, *H. connexus* and *H. cribrarius* were observed feeding greedily on the contents of *Nitella*, the softer portions of *Chara* and other filamentous algæ." Some years later, Pearce, (1921, p. 184) in speaking of the food habits of Haliplus, writes "In each case the specimens fed happily on the algæ, and were not observed seeking for animal food." Wilson (1923, p. 273) makes a rather definite statement about the food habits of *Peltodytes edentulus* Lec., "as far as observed they feed entirely upon *Chara* and *Nitella*" and also the same kind of statement

for *H. ruficollis* DeG. "They feed exclusively upon filamentous algæ." Falkenström (1926, p. 15) reached the same conclusion "Infolgedessen glaube ich feststellen zu können, dass nicht nur *H. immaculatus*, sondern auch mehrere andere Haliplidenarten, wenn nicht alle, Algenfresser sind, und dass sie nur in Ermangelung der Algen oder vielleicht anderer geeigneter Wassergewöchse bei störkerem Hunger animalische Nahrung ergreifen." The author's observations and results of various tests are in agreement in part with the above statements. Since the beetles will live a long time without apparent food, the problem was a very difficult one to solve. Records were obtained which showed that the beetles lived as long as a month and one-half in filtered, cistern water. Nothing was unusual about the habits of the beetles during the starving period up to a few days before death. So it was difficult to determine when they were receiving the proper nourishment. Great numbers were lost at first because from their behavior it was taken for granted they were getting the proper food. This seems to have been the same error made by other investigators. By means of an elimination test certain facts were obtained for the different species. Various kinds and combinations of aquatic plants and animals were tried. Such plants as *Spirogyra*, *Elodea*, *Chara*, *Nitella*, *Ceratophyllum*, *Lemna*, *Juncus*, *Ulothrix*, and unicellar algæ were used. Animals such as *Tubifex*, snails, Entomostraca, fresh beef, various insect larvæ, and dead beetles of the same family were also offered to the beetles as possible food. Although, when starved for a few days, they would attack and eat animal substances, but they were not kept alive very long on that kind of a diet.

Spirogyra proved to be the only kind of food that gave satisfactory results for four species, *Peltodytes edentulus* Lec., *P. sexmaculatus* Rbts., *P. lengi* and *Haliplus immaculicollis* Harr. Beetles of these species have now been kept living on this kind of food for eighteen months. During this time, they have laid eggs that hatched. *Nitella* was the only food that gave successful results for *Haliplus cribrarius* Lec., and *H. triopsis* Say. They have been kept alive for about nine months. The possibility that, in nature, other substances may be taken as food, is not necessarily ruled out, but satisfactory results have thus been obtained in the laboratory. With these things in mind it can be said that the beetles of the species studied are herbivorous and feed upon algæ.

No definite figures are known for the length of life of these beetles. The author kept beetles alive for eighteen months and they were still alive when the culture had to be discontinued. They were the first to be successfully cultured in the laboratory.

It was generally inferred that the beetles hibernate during the winter months, probably because they had never been collected. The author has collected them under 22 inches of ice, which had been on the lake for 3 months. The beetles were actively swimming about. While collecting through a hole in the ice individuals appeared at the surface and then dived. From the manner in which they came to the surface, it was decided that they must have had a bubble of air attached to the coxal cavity, otherwise, their behavior would have been entirely abnormal as has been shown in a previous paper (Hickman, in press). The question as to where they get the oxygen necessary for their activities during the winter has never been satisfactorily answered. Several theories have been advanced. Scott (1910, pp. 35–36) thinks that the filamentous algæ produce oxygen and that the *Typha* stems allow some gaseous exchange with the atmosphere. Wesenberg-Lund (1913, pp. 44–45) states that the aquatic beetles will collect in places where there are many green water plants and that they make use of the oxygen given off from them. The author's collecting experiences confirm Wesenberg-Lund's statement of the beetles' congregation at places where there are numerous green aquatic plants. Some of the largest collections made at one time were secured at such a place in the month of December. For example, during the past two winters, the beetles have been taken in numbers very much greater than during the summer at a patch of *Juncus* (bog-rush). Whether there is any connection between this particular water plant and the over-wintering of the beetle is not known. They are, however, very resistant to freezing, as tests in the laboratory show that they can be frozen solid in ice and still live. One test showed that beetles alternately frozen during the night and thawed out during the day over a period of twelve days were still alive. How long they could endure freezing is not known.

These beetles are not fast swimmers, a fact that Matheson (1912, p. 182) has already stated. "The swimming efficiency is very feeble as compared with the more specialized Dytiscidæ.

Instead of a soldering fast of the posterior coxæ and the formation of a solid joint, as in the Dytiscidæ, there is a remarkable plate-like development of the coxæ. By this means the hind legs are moved in one plane and their efficiency as swimming organs increased though their horizontal range of movement is, if anything, lessened." They will go to cover when disturbed and dig under the leaves or muck until they are hidden. Also they spend most of their time walking about over the vegetation rather than swimming. In this way they are not very noticeable and their larger enemies probably have more difficulty in finding them than if they were in open water. They have the death feigning habit and will remain motionless for a period of from a few seconds to several minutes when touched. This is a very good protective habit when out of the water as they sometimes are.

As early as 1880, Forbes recorded that *Haliplus* was eaten by *Semotilus corporalis* Mitch., the eastern chub. McAtee (1918) found beetles of this family in the stomachs of three species of Mallard ducks. Mabbott (1920) states these beetles were common in the stomachs of seven species of shoal ducks. No great amount of work was done on this subject but a few observations were made. The stomach contents of a sunfish taken at Douglas Lake included the elytra of a *Peltodytes* species. In the laboratory, they were eaten by frogs, *Dytiscus* adults and larvæ, and dragon-fly naiads. So it seems that most any aquatic insect eater might prey upon them.

In the course of dissecting some of these beetles there was found a stage of a water mite (*Hydracarina*) attached to the under side of the elytra. Pearce (1922, p. 37) had noticed the same for *Haliplus obliquus* Er. The author found them only in *Peltodytes edentulus* Lec., and *P. sexmaculatus* Rbts. The material was sent to Dr. Ruth Marshall, who identified and reported them (1927, p. 270) as the nymphal stage of *Eylais desecta* Koen. These water mites apparently do not seriously harm the beetles, as infested individuals isolated in November, 1926, are still alive (April, 1928). During the summer of 1927, these infested individuals laid eggs in the usual way. It seems likely that if the infestation be great they might interfere with the natural respiratory movements. Generally there is only one mite to a beetle but as many as six per host have been found.

The only record of copulation is that of Matheson (1912, p. 183, 186). He states that copulation takes place during the latter part of April and the month of May and that egg laying begins shortly afterwards. The author observed copulation in *Peltodytes edentulus* Lec., and *P. lengi* Rbts. in the last week of April and egg laying occurred one to two weeks later. Yet, a female beetle isolated in a culture in November of the previous year laid eggs about the 15th of May and normal larvæ hatched from them. It would thus seem that copulation took place as early as the fall before. Also copulation was noticed in the aquarium during the month of August for *H. immaculicollis* Harr. Still no eggs were laid in the culture that fall. More data are needed to clear up this point.

Egg-Laying Habits.

The period of egg-laying is very definite for the months of May, June and early part of July. There may be another one in the fall months as will be shown later in the discussion of the life cycle.

The number of eggs deposited by one individual varied from 30 to 40 but it was very hard to get a good count as they are not all laid at one time, but scattered over the period of a week or more. The time of laying varied greatly with different individuals. In a culture containing several females, eggs were collected from May first to July fifteenth and then only a few at a time.

The places where the eggs are laid are identical for the three *Peltodytes* species. They are laid on aquatic plants such as *Elodea*, *Ceratophyllum* and filamentous algæ. The previous statements are based upon field observations. In the cultures, they were laid on various things that might be in the aquarium. In several instances they were found on the long projections of *Peltodytes* larvæ which happened to be in the cultures with imagoes. There seemed to be no correlation of place of deposition with depth of water. Some were near the top and others under several inches of water. They were glued on one side to supporting objects but in no regular manner. *Haliplus immaculicollis* Harr. laid its eggs in holes which it cut in the stems of *Ceratophyllum*.

The process of egg-laying was observed but once and that for *Peltodytes lengi* Rbts. The female hunted around over the

branches until a suitable place was found and then deposited an egg. Actual laying required only a few seconds. Then the female moved a little and deposited another one. There seemed to be a sticky substance on the egg when first deposited which held the egg fast to the stem. This substance was all over the egg as instances were found where it was glued to more than one branch.

The chorion is sufficiently transparent to allow observations on development. After about 5 days, the six ocelli were observed as dark pigment bodies on each side of the egg. This fact was also observed by Falkenström (1926, p. 20). A few days later, faint outlines of body structure appeared. The larva lay on its back in the egg and the anterior and posterior ends were folded back upon the ventral surface. Body structures became more distinct up to the time of hatching and served as an indication of the hatching time, which took place about 8 to 10 days after oviposition.

The larva broke out slowly through a longitudinal slit which extended over the anterior end and more than half-way down each side of the egg. Those observed required about 3 hours from the beginning of hatching until they were free.

Habits of the Larva.

Larvæ of *P. edentulus* Lec., *P. sexmaculatus* Rbts., *P. lengi* Rbts. and *H. immaculicollis* Harr. were found among masses of filamentous algæ. At times they also occurred where no algæ were present, but this could be understood from the behavior of the algæ. Filamentous algæ, especially *Spirogyra*, are rather fast in growth and also fast in disappearance. Therefore on one date there might be a lot of the algæ at a particular spot and a few days later apparently none. Larvæ of *Haliplus cribrarius* Lec., and *H. triopsis* Say were taken only in *Chara* and *Nitella* beds and were therefore more restricted in habitat.

The larvæ are adapted only for crawling, and are very slow in their movements. Instead of hastening away when disturbed they will curl up and remain so for some time (3 to 6 minutes). They can not float but must reach the surface or shore by crawling over the vegetation or bottom.

The food without a doubt is algæ. The species of *Peltodytes* and *Haliplus immaculicollis* feed exclusively on filamentous algæ. The first pair of legs are particularly adapted for this

kind of food. By means of these legs they grasp the filament, pass it back in a hand-over-hand fashion until they reach the end. Then, they push it forward, at the same time puncturing each cell and sucking out the contents. They are very rapid feeders, and consume great quantities of algæ, especially when the larvæ are in the first and second instars. *Haliplus cribrarius* Lec., and *H. triopsis* Say feed upon Chara and Nitella, although in an entirely different manner. Their first pairs of legs are not adapted for grasping and passing the food to the mandibles as was previously stated for the filamentous algæ feeders. In fact, since Chara and Nitella are attached plants, they could not be so handled. Instead, the larvæ, after selecting a place to feed, scrape off the outside layer of the branches with the mandibles by means of a downward movement of the head, at the same time drawing in the loosened material through the suction canals. They usually begin to feed anywhere on the branches and make no effort to remove all of the layer but only in patches. Any slight disturbance in the cultures will stop them from feeding and many seconds usually elapse before beginning again.

The first and second larval instars are without spiracles so they must receive their oxygen by cutaneous respiration. The third larval instar of all the species studied has open spiracles and those of *Peltodytes* have the tracheæ extending out into the long body projections. These projections can be clipped off and still the larvæ will pupate. For that reason they must not be of vital importance. The third larval instar of *Peltodytes* species was thought not to have spiracles, but Steinke (1919, pp. 10–11) found them and the author has confirmed his results.

Only inferences can be stated about their protection. Presumably, the filamentous algæ feeders receive some protection by living on and within the algæ masses. They are not readily seen and their enemies are perhaps hindered by the strands from moving readily in search of these larvæ.

The *Chara* and *Nitella* feeders, it would seem, are protected from enemies by coloration and body forms, which are very similar to that of the plants. Also they are not easily detected by their movements as they are very slow crawlers.

Three instars are typical for beetle larvæ and it is very easy to distingusih them because the body projections become more complex for each instar. Head dimensions and total lengths

also are very dependable as characters for separating the instars.

Ecdysis was similar to that of other aquatic larvæ. A break in the skin occurred along the epicranial suture and extended posteriorly through the mid-dorsal line of the prothorax, mesothorax and metathorax. The process was very slow and required about two hours.

Generally speaking, of the beetles reared in the laboratory, the first larval stadium lasted about 5 to 7 days; second, 6 to 8 days, and third, 5 to 10 days. Very few larvæ died in the cultures even during the difficult and critical process of ecdysis which is some indication that the stadia were of normal duration. The last larval stadium may be much longer if conditions are not optimum for pupation. Many things prolonged these periods, such as starvation and low temperature. These stadia were about the same as reported by Matheson (1912, pp. 183–187).

Larvæ of the genus *Haliplus* were collected during the winter months and since the larvæ of all Michigan species were kept alive in the laboratory until February or later, it would seem that they will pass the winter in active form if conditions prevent them from pupating before cold weather appears. On December 19, 1927, larvæ of the second and third instars were taken under the ice at Geddes Pond. Second instar larvæ had not changed to the third larval instar as late as April 13, 1928, although they were kept in the laboratory at room temperature. Falkenström (1926, p. 12) states that for the most part they spend the winter above the water. The author's results do not confirm this statement.

The greatest enemy is probably fish, especially the minnows that live around among the algæ where the larval period of the beetle is spent. Wilson (1923, p. 260) gave evidence for this statement. Other things have attacked them in the laboratory, such as carnivorous insect larvæ and frogs. This suggests that possibly they are likewise enemies in nature. Various mites, crustaceans, and other organisms run over them, although no great harm was ever done in the cultures. In summer, enchytraeids were often wrapped around the larvæ, but there was no sign of resulting harm. On the whole, they were rather resistant to the smaller enemies. One added advantage is the fact that the larvæ are free from cannibalism and any number can be kept together.

A few days after the third larval instar was formed the larvæ began to wander about the culture apparently trying to get out. When allowed to get to shore material, they began to select the proper place in which to dig. After burrowing below the surface, up to a depth of one inch, they made a round cavity by digging the earth away and trampling it down. It required from one to three days to construct the chamber. After finishing the cell they curled up in the form of a semi-circle with the dorsal side resting on the floor of the cell and remained in this position for 2 to 4 days previous to pupation.

The Pupa.

The pupal period was 12 to 14 days. Although the pupa was completely buried and was in the dark, these conditions were not necessary for its development. Some of the cells were uncovered and exposed to light, yet the pupæ transformed normally.

Several times a cell was uncovered at the time of transformation. The pupa is a typical exarate type and the process of changing to adult is very similar to other beetles. Time required by the pupa to shed the exuvia is about twelve hours from the first apparent sign of activity to the end of process.

Life Cycle.

It has been definitely proven from cultures and field collections that there is a summer generation which includes the months of May, June, July and the first part of August for all the species studied and there are indications of another generation that begins in the fall and extends over to spring. For the summer generation, eggs are more numerous during the first part of May but may be found as late as the middle of July. Larvæ appear after about eight days and remain in the water at this stage for about three weeks including all instars. Then the larvæ seek the shore to pupate. The interval required from the time the larvæ enter the ground to their emergence is about two weeks. The imagoes seek the water immediately after leaving the pupa chambers. This whole period from egg to adult is about six weeks.

There may be another fall generation from the fact that larvæ of the second instar were collected in December and remained as such in the laboratory until the following April.

Summer collecting gave no indication that the earlier instars would remain that long. It was noticed while collecting at a particular spot that on one occasion a great majority of larvæ were taken in the first instar. A few days later, the greatest number were larvæ of the second instar and still a few days later the larvæ were almost all third instars with a few second and no first instars. It seems that this is a check on the data from laboratory cultures. However, the larvæ on the first and second instars never prolonged their period even when food was scarce, but the third instar will continue as such if not given a chance to pupate. The larvæ of the second instar, collected in December, were kept under the same conditions as the summer larvæ, yet the stadia were prolonged. Why was it prolonged in the winter and not in summer? The answer is not known but it would seem that it was due to something within the larva and not to outside factors.

Falkenström (1926, p. 13), unsuccessful in having the larvæ pupate under laboratory conditions, came to the conclusion that they do not naturally pupate during the same summer in which they are hatched. He states: "Die Larven erreichen wöhrend des Sommers ihres Ausschlöpfens nicht die Reife, um die Metamorphose durchmachen zu können, sondern öberwintern als Larven in verschiedenen Stadien."

As already indicated, the author's findings are entirely different from those of Falkenström and confirm even more definitely the earlier proposal of Matheson (1912, p. 191): "There is probably more than one brood a season."

It may be that Falkenström's difficulty in getting the larvæ to pupate was due to faulty culture methods, as the author has already stated that he himself experienced the same thing at first. However, when conditions were right the larvæ would pupate.

Conclusion.

1. Culture methods were developed for keeping the imagoes alive in the laboratory the year around, and for rearing these beetles from egg through all of the life history stages.

2. Imagoes and larvæ of the three species of *Peltodytes* and of *Haliplus immaculicollis* feed upon filamentous algæ, especially *Spirogyra*. *H. cribrarius* and *H. triopsis* feed upon *Chara* and *Nitella* in both mature and immature stages.

3. There is definitely one generation in the summer, and evidence of a fall generation that extends over to the following spring.

4. Both imagoes and larvæ spend the winter in the water, and manifest the same activities as during the summer.

5. The duration of the third larval instar can be prolonged for nine months or longer by keeping the larvæ in water and preventing them from reaching soil to pupate.

6. Nymphs of a water mite, *Eylais desecta* Koen, were found attached to the under side of the elytra of *Peltodytes edentulus* and *P. sexmaculatus*.

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KEY TO KNOWN PUPAE OF THE GENUS CALENDRA, WITH HOST-PLANT AND DISTRIBUTION NOTES

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Introduction.

The preparation of a table or "key" for determining the several species of beetles of the rhynchophorus genus *Calendra** in the pupa stage has been necessary in order to facilitate the study of the species involved in economic outbreaks.

This key has been in use at the Webster Groves, Missouri, field laboratory of the Bureau of Entomology since the winter of 1923-1924, and has evolved to its present state through adjustments made for the accommodation of additional species and of variants within species, as required by the increase in material at hand. Further changes in it will be necessary as knowledge of the pupa stage progresses.

The notes on geographical distribution given herein are only those gleaned by the writer from data attached to specimens of the species included in the present list of pupæ. These were either generously submitted by institutions and private collectors for study, or were obtained in the course of investigations in the field.

The arrangement of species of plants in the appended host-plant and plant-host lists is according to Gray's New Manual. The arrangement of the species of *Calendra* is according to Leng's List, with the possible exception of the place chosen for one form described since the List was published.

Descriptions of the pupa of each species are given, with a summary of the details used in the key for the species, followed by the description of one specimen of the species, in turn followed by the minimum and maximum measurements for the species, with average measurements and the number used in arriving at the averages.

Our knowledge of the geographical distribution of most species of *Calendra* is very incomplete and in only certain species has any definite value in this key. The apparently restricted occurrence of *Calendra phoeniciensis* in Arizona and of *C. discolor* in California and Oregon, will probably hold true only until a fairly careful survey is made of regions possessing similar ecological associations elsewhere. The occurrence of *C. ludoviciana* along the Gulf Coast and in southeastern Missouri indicates that little is known of billbug distribution

*Formerly *Sphenophorus*.

in the zone lying between the coast line and the latitude of Missouri, especially as the region includes the bottoms of several sluggish tributaries of the Lower Mississippi River. The occurrence of *C. retusa* in Florida, New Jersey and Massachusetts, may bear a consistent relationship to coastal distribution, but the seasonal occurrence of pupæ cannot be expected to be similar in the remote latitudes.

Discussion of Characters.

The genus *Calendra* comprises a taxonomically difficult group of destructive insects popularly known as "billbugs." It consists of seventy-five or more species within the United States and numerous other species not occurring in this country. Distinguishing characters in the adult stage are often obscure, and in the pupa stage are fairly liquid.

Size in these insects, which dig their livelihood out of the interior of short-lived plants, is particularly variable. If the plant dies before the immature insect is sufficiently near maturity to complete its development, the insect must migrate to other food or die. Nature allows the insect some leeway, however, in the matter of development and it can mature with reduced growth in the event of reduced food. As a consequence, although the adult females average larger than the males, some females at maturity are much smaller than the average males and there is nearly 100 percent difference in length between the smallest and the largest billbugs of the same sex and the same species. Like variation must be expected in the pupæ of these insects.

The season of occurrence of the pupa stage has not been utilized in the key, because the differences of season in the latitude of St. Louis and northward are insufficient to have real value, and the geographical distribution aids directly in the differentiation of those species which extend far enough south to be seasonally different.

A study of the distinguishing characters in the pupæ of the species of *Calendra* could not profitably be conducted until many specimens known to be of one species could be analyzed and a fair valuation of characters thus be established.

Numerous adults of *Calendra retusa* were obtained in 1922 and 1923, from which many eggs were obtained and pupæ reared. Descriptive notes were made of over one hundred

pupæ of this species and an attempt was made to count and tabulate all setæ borne by every anatomic part. The dorsal setæ of the first six abdominal segments and all lateral setæ, except in some instances the stigmatal setæ of the pronotum, are ignored as having insufficient value to merit counting. The dorsal setæ located on the seventh and ninth abdominal segments are usually eight or ten, in groups of four or five, and are rarely of specific value.

The setæ which have proved most nearly constant are those of the rostrum, pronotum, mesonotum, metanotum, and eighth tergite.

The setal armature of the rostrum consists of two, three, four, or five pairs, regularly spaced, sometimes with promiscuously placed extra setæ. The number most frequently observed is three pairs, the basal often arising from conspicuous prominences or irregularly wrinkled areas located nearly over the posterior extremities of the compound eyes. The apical pair of the three-pair set is placed on the arch of the antennæ, usually posterior to the point of attachment of the antennæ. When the armature is limited to two pairs, the basal of the three-pair set is wanting and the positions of the two remaining pairs continue as before. When one or more pairs are added in regular spacing, they are located between the antennal arch and the apex of the rostrum.

Each seta has a conical base, sometimes somewhat flattened transversely, almost always smooth. The basal setæ may be located on a smooth contour of the head, or on the prominences previously mentioned. These prominences afford aid in the determination of many of the species included in this paper. They are elusive, in that they vary from a practically plain contour to a group of miniature tubercles in *pertinax*, or they may be high, almost cylindrical, excrescence-like, as in *melanocephala*, broad and overhanging laterad, as in *ludoviciana*, broad and nearly circular, or narrow, transverse oval areas. The degree of height in the broad prominences is difficult to define. Variations within species have necessitated keying out several species at two or more places.

On the pronotal disc are paired setæ at the four front and back corners, and at the middle. These are designated, respectively, "prolatero-pronotal," "postlatero-pronotal," and "medio-pronotal" setæ. There are usually two pairs of prolatero-pronotals and of postlatero-pronotals and rarely two pairs, usually one pair, often no pair of medio-pronotals.

On the sides of the pronotum there are usually two pairs of fine setæ, the "spiraculo-pronotal" setæ. Frequently these are so fine as to defy discovery except with high magnification, good illumination, and more patience than this character merits. However, in some species the spiraculo-pronotals are as large as the largest on the disc, and sometimes the location of one or both pairs will be at the edge of the disc or conspicuously separated from each other, or one pair will be conspicuously close to the outer postlatero-pronotal setæ.

On the mesonotum and metanotum there are generally two pairs, varying from none to three or four pairs on one or both.

On the eighth tergite there may be two setæ, sometimes as large as the largest on the seventh or ninth, two spots indicating that setæ had been there, or ought to have been there, or no trace of setæ. In some species there are usually several small setæ in addition to the large setæ, if the latter are present.

The length of the rostrum is measured by its termination at the cephalic margin, at the middle, past the middle, or beyond the caudal margin of the apices of the first pair of tibiæ.

The measurement of width of pronotum is the greatest width across the disc, without regard to the appendages. The total length is normally that at which the pupa will cease to be held between the jaws of the caliper at the up-turn of the measurement screw. It is possible that the setæ may serve to a slight extent to retain the pupa in the caliper beyond the actual measure of the flesh, but the correction of this small error was impracticable.

A word concerning the caliper used may be helpful. It is a sliding type for outside and inside calibration to 0.01 mm. To avoid error by reason of looseness, all measurements are taken on the up-turn from a starting point of tight contact of the jaws, opening at zero. The calibration on the bar is to 0.5 mm., for 10 cm. The adjustment for the reading is by a thumb screw graduated to fiftieths and makes one cycle to each 0.5 mm.

The determination of the sex in the pupa is made chiefly on the presence of a longitudinal impressed or stained line on the ventral surface, basal half, of the ninth segment, but sometimes reaching across the eighth and onto the seventh sternite. This line is absent in the male. Well-marked females have a pair of blunt conical projections on the ventral surface, just cephalad of the clusters of setæ of the ninth tergite. As the pupa nears maturity, the terminus of the pygidium and of the eighth tergite often shows the truncate character of the male or the acuminate character of the female.

Color does not appear to have specific value. All the pupæ are white, wood ivory, or creamy white, varying somewhat with age, possibly with environment, but chiefly with age. The prominences upon which the basal tubercles of the rostrum develop, color up in a few species, notably in *callosa* and *setiger*.

Description of Pupæ.

Calendra inaequalis (Say).

Rostrum with six regular, seta-bearing tubercles, with or without additional, promiscuously placed, seta-bearing tubercles, the basal pair set on broad, irregular prominences, moderately high and moderately wrinkled; two large medio-pronotal setæ; four large and two small spiraculo-pronotal setæ; all setæ conspicuously barbed; length, 7.81 to

8.25 mm., average (2), 8.03 mm.; pronotal width, 2.78 to 2.98 mm., average, 2.88 mm.

Female. Length, 8.25 mm.; pronotal width, 2.98 mm. Rostrum with seven conical, seta-bearing tubercles, basals on narrow, oval, low prominences, transversely placed; surface irregular, the irregularities somewhat regularly transverse, and becoming transverse rings from apical tubercles to apex of rostrum; a median line from basals to a point two-thirds forward from second to third pairs of tubercles. Apex above scarcely concave. The seventh seta-bearing tubercle is placed cephalo-mesad of the middle left tubercle, and is very small. Rostrum robust, short, extending about one-third across the protibiæ. Basal setæ set much closer to each other than are the individuals in the other pairs; longitudinal spacing uniform. Prolatero-pronotal setæ, four; postlatero-pronotal setæ, four large setæ and, on right, a small extra seta; medio-pronotals, two; spiraculo-pronotals, four large and two small setæ; mesonotals, four; metanotals, three left, two right; setæ of eighth tergite wanting. All setæ are strongly barbed. Those of thorax are all notably coarse, except those noted as small. The spiraculo-pronotal setæ are two coarse setæ set close together on edge of pronotal disc, each side, and one small seta each side, much nearer the spiracle. The regular postlatero-pronotal setæ are widely separated; the supplementary seta is near the left, outer postlatero-pronotal seta. The medio-pronotals are only slightly caudad of line between posterior setæ of the prolatero-pronotals. The mesonotal and metanotal setæ are unusually large and closely set on their respective areas. The tips of the elytra are strongly developed, not so vertical as in some species, but the portion caudad of the point is bent back strongly toward body. The pupa appears robust.

Description from reared live pupa, specimen 28110a.

Calendra aequalis (Gyll.).

Rostrum with six seta-bearing tubercles only, all conical, basal pair set on broad, irregular prominences, high, deeply wrinkled, sides rounded, or not set on such prominences; mesonotal setæ usually four or more, sometimes two; medio-pronotal setæ rarely more than two, occasionally wanting; setæ of eighth tergite wanting; length, 14.77 to 23.00 mm., average (12), 18.49 mm.; pronotal width, 4.36 to 6.49 mm., average, 5.73 mm.

Male. Length, 17.52 mm. Rostrum with six conical, seta-bearing tubercles, the basal pair set on irregular prominences. Prolatero-pronotal and postlatero-pronotal setæ, four each; medio-pronotals, two; spiraculo-pronotals wanting; mesonotals, six; metanotals, four; setæ of eighth tergite wanting.

Description from preserved wild pupa, specimen 22717. See dorsal and ventral views of this male and lateral and ventral views of a female from same collection, Pl. I, Figs. 1–4.

Length, from 14.77 to 23.00 mm.; average (7), 17.60 mm.; pronotal width, 4.36 to 6.49 mm.; average, 5.47 mm.

Calendra discolor (Mann.).

Rostrum with six or more regularly spaced, seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, moderately high and wrinkled; two or more setæ on eighth abdominal tergite; no spiraculo-pronotal and never more than two medio-pronotal setæ; length, 11.66 to 19.00 mm., average (8), 17.26 mm.

Male. Length, 15.75 mm. Rostrum with eight conical, seta-bearing tubercles, basal pair set upon a wrinkled, fairly high prominence. Prolatero-pronotal setæ apparently six, but as the medio-pronotal setæ are not in the region of the median line, presumably they have migrated to the region of the prolatero-pronotals; postlatero-pronotals, four; spiraculo-pronotals wanting; mesonotals, two left, one right; metanotals, four; setæ of eighth tergite, three left, two right, all small.

Description from preserved wild pupa, specimen 21009bu, contributed by C. M. Packard, from tule marsh, Rio Vista, Calif. See illustrations, full dorsal and full lateral views and view of segments seven to ten, of abdomen, Pl. I, Figs. 5–7, respectively.

Length, 11.66 to 19.00 mm.; average (8), 17.26 mm.

Calendra pertinax (Oliv.).

Rostrum with six regular tubercles or basal pair replaced with a rippled, slightly elevated contour of the head or with a cluster of miniature tubercles, only the cephalad four tubercles bearing setæ; basal pair of tubercles never tall-rosetted or excrescence-like, but resembling the forward ones if present.

Female. Length not recorded. Rostrum with basal tubercles fairly definitely defined, but with all tubercles small as compared with those of most other species; the four cephalad tubercles conical, seta-bearing. Prolatero-pronotal setæ three, two left, one right; postlatero-pronotals, four; medio-pronotals, spiraculo-pronotals, and mesonotals, wanting; metanotals, two; setæ of eighth tergite wanting.

Description from a wild, preserved pupa, specimen 1992t. See illustrations of this pupa, showing full side view and ventral or face view of head, Pl. I, Figs. 8, 9.

Length, from 10.99 to 16.12 mm.; average (20), 13.74 mm.; pronotal width, 3.44 to 4.52 mm.; average, 3.81 mm.

Calendra setiger (Chttn.).

Rostrum with only six seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, high, deeply wrinkled, overhanging laterally; mesonotal setæ, four; basal tubercles in their entirety appearing as hemispheres cut under at outer edge or circular with high vertical boundaries.

Female. Length, 13.21 mm.; pronotal width, 3.53 mm. Rostrum with six conical, seta-bearing tubercles, the basals finely wrinkled, set on deeply wrinkled, nearly hemispherical prominences, overhanging

cephalad-laterad, darker than rest of head, appearing to unaided eye as two projecting red points. Rostral setæ uniformly large, second and third pairs in parallel lines, the basals wider apart. Apex of rostrum reaching slightly beyond the protibiæ. Prolatero-pronotal and postlatero-pronotal setæ, four each; medio-pronotals, two; spiraculo-pronotals, one left, two right; mesonotals and metanotals, each two; setæ of eighth tergite merely indicated by two spots. The medio-pronotals are as large as the largest of the notal setæ.

Description from living reared pupa, specimen 26037a.

Length, from 11.70 to 14.36 mm.; average (50), 13.09 mm.; pronotal width, 2.88 to 4.15 mm.; average, 3.61 mm.

Calendra ludoviciana (Chttn.).

Rostrum with only six seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, high, deeply wrinkled, laterally overhanging; mesonotal setæ, two, rarely none or three; or prominences low-domed, area oval.

Length, 13.75 to 18.50 mm., average (2), 16.12 mm.; pronotal width, 3.79 to 4.75 mm., average, 4.27 mm.

Female. Length, not recorded. Rostrum with six conical, seta-bearing tubercles, the basal pair set on large, irregular, wrinkled prominences, overhanging in fullness laterad and occupying an oval area. Prolatero-pronotal setæ, one left, two right; postlatero-pronotals, two; medio-pronotals, two; mesonotals, two; metanotals, two; setæ of eighth tergite, two, small.

Description from preserved wild pupa, specimen 183801.

See full lateral view and caudal view of this female and the caudal view of male of same species, specimen 18389, from same infestation, Pl. I, Figs. 10–12, respectively.

Length, from 13.75 to 18.50 mm.; average (2), 16.12 mm.; pronotal width, 3.79 to 4.75 mm.; average, 4.27 mm.

Calendra robusta (Horn).

Rostrum with six, eight, or ten regular, seta-bearing, conical tubercles, the basal pair set on broad, irregular prominences, high, deeply wrinkled, sides rounded; mesonotal setæ usually four or more, sometimes two; medio-pronotal setæ, usually two, never more, sometimes wanting; length, 11.65 to 15.63 mm., average (18), 13.52 mm.; pronotal width, 3.11 to 4.64 mm., average, 3.82 mm.

Male. Length, 13.24 mm.; pronotal width, 3.76 mm. Rostrum with nine seta-bearing, conical tubercles, with mark representing the tenth. Basals on strongly raised and wrinkled transverse-oval prominences. Setal lines of the basal, second, and third pairs almost parallel. The fourth pair is very small, situated cephalad-mesad of third pair and about one-fourth the space between setal lines from third pair. The fifth pair is represented on the right by a fair-sized tubercle and seta, on the left by a mere mark, two-thirds of the distance from the

third pair to the apex of the rostrum. Rostrum reaching middle of protibiæ. Prolatero-pronotal setæ, four; postlatero-pronotal setæ, four; medio-pronotals, two; spiraculo-pronotals, four; mesonotals, two left, three right; metanotals, six; setæ on eighth tergite wanting. The apical third of that portion of the rostrum beyond the point of attachment of the antennæ is reduced in diameter. Sides of head with jowls, top of head not uniformly curved. Median rostral line depressed from near basals to near the third pair of tubercles. Rostrum beyond antennæ with transverse rugæ, nearly annulate. The basal prominences are deeply wrinkled, the deepest cleft being transverse, cephalad to the cones. There are about three clefts laterad of each cone.

Description from a pupa which yielded the adult, 26066o.

The pupa of this species is very much like the pupa of *C. aequalis*. There is a marked difference of 4 mm. in average lengths, with an overlap in a few individuals, *aequalis* being the larger. The prominences of the basal rostral tubercles are somewhat higher and narrower in *robusta* than in *aequalis*.

Lengths, from 11.65 to 15.63 mm.; average, (18) 13.52 mm.; pronotal width, 3.11 to 4.64 mm.; average, 3.82 mm.

Calendra costipennis (Horn).

Rostrum with only six seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, high or moderately high, deeply or moderately wrinkled, sides rounded; mesonotal setæ usually four or more, sometimes two; medio-pronotal setæ usually wanting, but may be two or four; length, 9.10 to 14.78 mm., average (43), 11.09 mm.; pronotal width, 2.30 to 4.22 mm., average, 3.27 mm.

Male. Length, 10.50 mm.; pronotal width, 3.53 mm.

Rostrum with six conical, seta-bearing tubercles, the basal pair set upon prominences which are broad, low, and nearly circular. Rostrum reaching fully across the protibiæ. Prolatero-pronotal setæ, one left, none right; postlatero-pronotals, four, of which the outer are very tiny; medio-pronotals, spiraculo-pronotals, and mesonotals, wanting; metanotals, two; setæ of eighth tergite wanting.

Description from reared living pupa, specimen 24094i.

Lengths, from 9.10 to 14.78 mm.; average (43), 11.09 mm.; pronotal width, 2.30 to 4.22 mm.; average, 3.27 mm.

Calendra costicollis var. **callosipennis** (Chttn.).

Rostrum with only four tubercles, all seta-bearing. Eighth abdominal tergite without large setæ. Setæ of median and spiracular areas of pronotum and setæ of mesonotum usually wanting.

Male. Length, 12.16 mm.; pronotal width, 4.63 mm. Rostrum with four setæ; terminating at caudal margin of protibiæ; area of head in region of caudal margin of compound eyes slightly wrinkled. Prolatero-pronotal setæ, two left, one right; postlatero-pronotals, four;

medio-pronotals, spiraculo-pronotals, mesonotals, and meatanotals wanting; setæ of eighth tergite wanting.

Description from living, reared pupa, specimen 24174d.

Lengths, from 8.76 to 15.95 mm.; average (10), 12.55 mm.; pronotal width, from 2.54 to 6.5 mm.; average (10), 4.13 mm.

Specimen 21173g, a male, is represented by illustrations of full dorsal aspect, side view of head and thorax and of caudal end, showing the greatly reduced armature of setæ of this species, Pl. I, Figs. 13–15.

Calendra maidis (Chttn.)

Rostrum with six regular, seta-bearing, conical tubercles, with or without additional, promiscuously placed, seta-bearing tubercles, the basal pair set on broad, irregular prominences, high and deeply wrinkled or moderately high and moderately wrinkled; usually four medio-pronotal setæ; mesonotal setæ usually four or more, sometimes two; spiraculo-pronotal setæ usually four, rarely wanting; setæ on eighth tergite very small or wanting; length, 11.11 to 18.00 mm., average (30), 14.05 mm.; pronotal width, 3.44 to 6.45 mm., average, 4.64 mm.

Female. Length, 15.04 mm. Rostrum with six conical, seta-bearing tubercles, the basals set upon broad, irregular prominences, the basal, second, and third pairs normally spaced. Prolatero-pronotal, postlatero-pronotal, medio-pronotal, and spiraculo-pronotal setæ, four each; meso-notals, six; metanotals, four; setæ of eighth tergite wanting.

Description from freshly killed, reared pupa, full lateral and dorsal views illustrated on Pl. II, Figs. 16–17, respectively.

Length, from 11.11 to 18.00 mm.; average (30), 14.05 mm.; pronotal width, 3.44 to 6.45 mm.; average, 4.64 mm.

Calendra cariosa (Oliv.).

Rostrum with only six seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, moderately high and wrinkled, narrower than in *discolor* and *maidis*, species usually medium or small; prominences not darker than head, base wrinkled, not appearing lobed or granular. Length, 8.31 to 17.00 mm., average (10), 12.49 mm.; pronotal width, 2.66 to 4.40 mm., average, 3.55 mm.

Male. Length, 10.96 mm.; pronotal width, 3.23 mm. Rostrum with six conical, seta-bearing tubercles, the basals without particular prominences; apex reaching beyond protibia, fairly smooth, flattened or concave at apex above. Wing pads without points. Prolatero-pronotal setæ, two tiny, two very tiny; postlatero-pronotals, two small, two tiny; medio-pronotals, two, small; spiraculo-pronotals, tiny; mesonotals, two very tiny; metanotals, two, small; setæ of eighth tergite, two, very short, stout.

Description from live reared pupa, specimen 28136c. See full ventral and lateral illustrations of male *cariosa*, specimen 2028c. Pl. II, Figs. 19a, b, and dorsal and ventral views of ♀, Figs. 18a–b.

Length, from 8.31 to 17.00 mm., average (10), 12.49 mm.; pronotal width, 2.66 to 4.40 mm.; average, 3.55 mm.

Calendra parvula (Gyll.).

Rostrum with only four tubercles, all seta-bearing. Eighth abdominal tergite with one pair of large dorsal setæ as large as largest on ninth tergite. Species small, slender, length from 5.58 mm. to 10.22 mm., pronotal width, from 1.93 to 3.98 mm.; beak appearing long and slender; large setæ of ninth tergite six or eight, usually eight.

Male. Length, 7.09 mm. Rostrum with four seta-bearing tubercles the apical pair slightly caudad to middle of point of attachment of antennæ, the second pair in front of eyes at base of rostrum. Prolatero-pronotal setæ, four, the outer pair much farther forward than the inner pair; postlatero-pronotal setæ, four, the outer not quite so far forward of the inner as in the prolatero-pronotals; medio-pronotal and spiraculo-pronotal setæ wanting, as also those of the mesonotal and metanotal areas. Two large setæ on eighth tergite. Description from living, reared pupa. Specimen 2340m, preserved. See illustrations of lateral and ventral aspects and dorsum of thorax, Pl. II, Figs. 20–22.

The average length of 73 specimens, of which both the length and the pronotal width were recorded, is 8.47 mm., the average pronotal width, 2.51 mm.

Calendra minima (Hart).

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; outer postlatero-pronotal seta much nearer to inner postlatero-pronotal seta than to either spiraculo-pronotal seta; upper spiraculo-pronotal seta much nearer to lower spiraculo-pronotal than to outer postlatero-pronotal seta; length, 6.46 to 8.69 mm., average (15), 7.50 mm.; pronotal width, 1.85 to 2.50 mm., average, 2.15 mm.

Female. Length, 7.87 mm., pronotal width, 2.21 mm. Rostrum with six seta-bearing, conical tubercles, no basal prominences; basal setæ about half the length of second setæ. The head merges into the rostrum gradually, giving it a particularly massive appearance. Apex of rostrum reaching past the middle of the protibiæ. Prolatero-pronotal and postlatero-pronotal setæ, each four; medio-pronotal setæ, two; spiraculo-pronotal setæ, four; mesonotal setæ, two; metanotal setæ, four; setæ of eighth tergite, two, one as large as largest on ninth tergite, the other less than half the size; setæ of seventh tergite high-crested. All pronotal setæ are coarse and all are visible from the dorsal view, giving the species a very spiny appearance, conspicuously more so than that of *parvula*.

Description from wild pupa which yielded an adult *minima*, specimen 26049u. See illustrations of side view and view of caudal end of female *minima*, specimen 23721a, Pl. II, Figs. 23–24.

Length, from 6.46 to 8.69 mm.; average (15), 7.50 mm.; pronotal width, 1.85 to 2.50 mm.; average, 2.15 mm.

Calendra retusa (Gyll.)

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; mesonotal and metanotal setæ, one or more pairs each; setæ of eighth tergite, two large, dorsal, rarely irregular, no small setæ; length, 8.90 to 11.00 mm., average (10), 10.04 mm.; pronotal width, 2.75 to 3.42 mm., average, 3.05 mm.

Female. Length not recorded. Rostrum with six conical, seta-bearing tubercles, without basal prominences. Prolatero-pronotal and postlatero-pronotal setæ, four each; medio-pronotal setæ, one left, two right; spiraculo-pronotal setæ, four; mesonotal and metanotal setæ, each two; setæ of eighth tergite, two, large.

Description from freshly killed, reared pupa, specimen 23731ar. See full dorsal and ventral illustrations, showing the setal armature of the species, Pl. II, Figs. 25, 26.

Length, from 8.90 to 11.00 mm.; average (10), 10.04 mm.; pronotal width, 2.75 to 3.42 mm.; average, 3.05 mm.

Calendra destructor (Chttn.).

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; mesonotal and metanotal setæ each one or more pairs; setæ of eight tergite, one large dorsal pair, usually one or two pairs of small setæ; length, 8.05 to 10.84 mm., average (10), 9.46 mm.; pronotal width, 3.00 to 4.65 mm., average, 3.97 mm.

Female. Length not recorded. Rostrum with six conical, seta-bearing tubercles, none on prominences. Spaces between setæ, transversely and longitudinally, about twice the length of the setæ. Prolatero-pronotal and postlatero-pronotal setæ, four each; medio-pronotal setæ, two; spiraculo-pronotal setæ, four; mesonotal and metanotal setæ, each two; setæ of eighth tergite, eight, two large, dorsal, six small.

Description from living, reared pupa, specimen 23188j. See full dorsal, lateral, and ventral illustrations and illustration of last four segments of abdomen, caudo-ventral view, showing setæ of seventh, eighth, and ninth tergites, Pl. III, Figs. 27, 28, 29, 30, respectively.

Length, from 8.05 to 10.84 mm.; average (10), 9.46 mm.; pronotal width, 3.00 to 4.65 mm.; average, 3.97 mm.

Calendra zeæ (Walsh).

Rostrum with only four tubercles, each seta-bearing; eighth abdominal tergite without large setæ; medio-pronotal, spiraculo-pronotal, and mesonotal setæ not all wanting; species small, 12 mm. or less.

Female. Length, 11.44 mm.; pronotal width, 3.20 mm. Rostrum with four conical tubercles, each seta-bearing. Prolatero-pronotal setæ, four, small, one very tiny; postlatero-pronotals, four, rather short, coarse, fairly approximate; medio-pronotals wanting; spiraculo-pronotals, four, very small, nearer each other than either to spiracle; mesonotals wanting; metanotals, four; setæ of eighth tergite wanting.

Description from living, reared pupa, specimen 25087d.

Length, from 6.69 to 11.60 mm.; average (14), 9.41 mm.; pronotal width, 2.11 to 3.59 mm.; average, 2.97 mm.

One specimen of this species showed an absence of one of the regular rostral setæ on one side and the development of one cephalad of the regular series, indicating a tendency to instability in the setal characters of the rostrum in this species.

Calendra scoparia (Horn).

Rostrum with only four tubercles, all seta-bearing; eighth abdominal tergite without large setæ; medio-pronotal, spiraculo-pronotal, and mesonotal setæ not all wanting; species large, 14 mm. or longer, or rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; mesonotal setæ wanting; average size, larger than *venatus*.

Female. Length not recorded. Rostrum with four setæ; prolatero-pronotal setæ, four, nearly central in their respective cephalic quarters; postlatero-pronotals, four; medio-pronotals wanting; spiraculo-pronotals, four, one near each spiracle, the other, very small, two-thirds of the way up from the spiracle to the postlatero-pronotals; mesonotals wanting; metanotals, two normal, two very tiny; setæ of eighth tergite wanting.

Description from living, reared pupa, specimen 23112a. See dorsal and ventral aspects of full-length pupa and side of caudal end, illustrating arrangement or absence of setæ, Pl. III, Figs. 31–33.

Length, from 11.86 to 15.37 mm.; average (13), 13.65 mm.; pronotal width, 3.50 to 4.71 mm.; average, 4.04 mm.

Calendra callosa (Oliv.)

Rostrum with six regular tubercles, all or only the cephalad four bearing setæ; all conical, the basals set on three-lobed or granular bases, usually darker than the head, sometimes on broad, irregular prominences, moderately high and wrinkled, narrower than in *discolor* and *maidis*. Species usually medium or small, rarely more than 13 mm. long.

Female. Length not recorded. Rostrum with four conical, seta-bearing tubercles cephalad of the basal, non-seta-bearing, prominent granular tubercles, darker than the head. Prolatero-pronotal setæ, four; postlatero-pronotals, four; medio-pronotals, spiraculo-pronotals, and mesonotals, wanting; metanotals, two; setæ of eighth tergite wanting.

Description from wild alcoholic pupa, specimen 18347f. See illustrations of this specimen, showing full dorsal and ventral surfaces, with face and notal characters, Pl. III, Figs. 34, 35. See also the illustration of male pupa 23700s, ventral view, Pl. III, Fig. 36.

Length, from 8.17 to 12.83 mm.; average (40), 10.35 mm.; pronotal width, 2.51 to 4.50 mm.; average, 3.27 mm.

Calendra melanocephala (Fab.).

Rostrum with six regular tubercles, only the cephalad four bearing setæ; basal pair of tubercles tall-rosetted, excrescence-like; medio-pronotal setæ wanting; basal rostral tubercles large; space between these usually less than half the diameter of either.

Female. Length not recorded. Rostrum with six tubercles, the basal pair tall-rosetted, without setæ; four cephalad tubercles simple cones, each seta-bearing. Prolatero-pronotal not recorded; postlatero-pronotals, four; medio-pronotals wanting; spiraculo-pronotals, one tiny seta observed on right edge of disc, others not found; mesonotals wanting; metanotals, one found on right side; setæ of eighth tergite wanting.

Description from wild pupa, specimen 18252a. See illustration of entire ventral aspect, especially portraying the rostral tubercles and setæ, Pl. III, Fig. 37. Also, see illustration of thorax, showing paucity of notal setæ, and illustration of caudal end of body, ventral view, and entire lateral and ventral views, all of specimen 20111i, a male, Pl. III, Figs. 38, 39, 40, 41.

Length, from 10.27 to 10.35 mm.; average, 10.31 mm.; pronotal width, 4.29 to 4.53 mm.; average (2), 4.41 mm.

In other specimens, the prolatero-pronotal setæ were sometimes wanting, some had one, some had two, and one had three.

Calendra pontederiæ (Chttn.).

Rostrum with six regular tubercles, only the cephalad four bearing setæ; basal tubercles tall-rosetted, excrescence-like; medio-pronotal setæ present.

Female. Length not recorded. Rostrum with six tubercles, the basal pair tall-rosetted, without setæ; four cephalad tubercles simple cones, each seta-bearing. Prolatero-pronotal setæ, four; postlatero-pronotals, four; medio-pronotals, two; spiraculo-pronotals, four; meso-notal and metanotal setæ wanting; two large, distinctly capitate setæ and four small setæ on eighth tergite. The spiraculo-pronotal setæ are very tiny, just below the edge of the pronotal disc.

Description from preserved, reared pupa, specimen 22177p.

Calendra venatus (Say).

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; mesonotal setæ present or wanting; setæ of eighth tergite present; metanotal setæ, one or more pairs; length, 9.22 to 12.75 mm., average, (68), 10.81 mm., pronotal width, 2.32 to 3.79 mm., average, 3.05 mm.

Female. Length not recorded. Rostrum with six conical seta-bearing tubercles, without basal prominences. Prolatero-pronotal and postlatero-pronotal setæ, four each; medio-pronotal setæ, two; spiraculo-

pronotal, mesonotal, and metanotal setæ, four each; setæ of eighth tergite, two large and two small setæ.

Description from preserved reared pupa, specimen 23128h. See full dorsal and lateral illustrations of this species, Pl. III, Figs. 42–43.

Length, from 9.22 to 12.75 mm.; average (68), 10.81 mm.; pronotal width, 2.32 to 3.79 mm.; average, 3.05 mm.

Calendra phoeniciensis (Chttn.).

Rostrum with only four tubercles, all seta-bearing. Eighth abdominal tergite with one pair of large dorsal setæ as large as largest on ninth tergite. Species small, slightly more robust than *parvula;* length, from 7.89 to 9.02 mm., pronotal width, from 2.43 to 3.46 mm.; beak appearing stocky; large setæ of ninth tergite four to six, usually six.

Female. Length, 9.45 mm.; pronotal width, 2.62 mm. Rostrum with four conical tubercles, each seta-bearing; stocky, yet reaching beyond middle of front tibiæ; sculptured by about eighteen distinct and six faint rings between setæ and apex; apex concave above, in median line, the depression interrupting the transverse rings. Prolatero-pronotal setæ, one, normal, and one, half length; postlatero-pronotals, two; medio-pronotals, mesonotals, and metanotals wanting; seventh tergite, five; eighth, two, large; ninth, six.

Description from living, reared pupa, specimen 28005h.

The prolatero-pronotal setæ of this species are usually two pairs, one pair of normal size, the other of very minute setæ. The rostrum frequently shows a rippled surface at its base, about the region of the posterior ends of the compound eyes.

Calendra incongrua (Chttn.).

Rostrum with six regular tubercles, only the cephalad four bearing setæ; basal pair of tubercles tall-rosetted, excrescence-like; medio-pronotal setæ absent; basal rostral tubercles smaller than in *melanocephala;* space between these usually more than half the diameter of either.

Female. Length, 11.29 mm.; pronotal width, 2.86 mm. Rostrum with basal tubercles tall-rosetted, without setæ, darker than rest of head, about three-fifths of the diameter of the tubercle between them; four anterior tubercles conical, seta-bearing. Setal lines diverging slightly apically. Rostrum extending beyond the protibiæ. Prolatero-pronotal setæ, four; postlatero-pronotal setæ, four; medio-pronotals, spiraculo-pronotals, mesonotals, metanotals, and setæ of eighth tergite, wanting.

Description from pupa 26060a which yielded an adult. The postlatero-pronotal setæ are almost always all present, the prolatero-pronotals are wanting in about seven per cent. The rostral tubercles and setæ are almost perfectly constant. One specimen had a supernumerary tubercle with seta. The space between the basal tubercles

varies from less than half to more than three-quarters of the diameter of either between them, though usually they are more than half the diameter apart.

Length, from 7.00 to 12.07 mm.; average (106), 10.23 mm.; pronotal width, 2.02 to 3.91 mm.; average, 2.65 mm.

Calendra oblita (Lec.).

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; outer postlatero-pronotal seta much nearer to upper spiraculo-pronotal seta than to inner postlatero-pronotal seta. Upper spiraculo-pronotal seta much nearer to outer postlatero-pronotal seta than to lower spiraculo-pronotal seta. Length, 7.30 to 10.53 mm., average (15), 8.89 mm.; pronotal width, 2.24 to 3.37 mm., average, 2.80 mm.

Male. Length, 8.35 mm.; pronotal width, 2.90 mm. Rostrum with six conical, seta-bearing tubercles, without any basal prominence; basal tubercles nearly transverse; space between basal and second tubercles two-thirds as great as space between second and third tubercles. Prolatero-pronotal setæ, four; postlatero-pronotal setæ, four, the outer much nearer to upper spiraculo-pronotal setæ than to inner; medio-pronotal setæ, two; spiraculo-pronotal setæ, four, the upper much nearer to outer postlatero-pronotal setæ than to lower, *i. e.*, the upper spiraculo-pronotal seta is twice as far from the lower spiraculo-pronotal as from the outer postlatero-pronotal seta, and the space between the inner and outer postlatero-pronotal setæ is one and one-half times the space between the outer postlatero-pronotal and the upper spiraculo-pronotal setæ; mesonotal setæ, six, one on each side, being in front of base of elytra; metanotal setæ, four left, three right; setæ of eighth tergite, two large. Head non-symmetrical, wrinkled.

Description from living reared pupa, specimen 25102a.

Length, from 7.30 to 10.53 mm., average (15), 8.89 mm.; pronotal width, 2.24 to 3.37 mm., average, 2.80 mm.

KEY.

a. Rostrum with only four seta-bearing tubercles, or if more, the additional setæ obviously not of standard series.

b. Rostrum with only four tubercles, or, if more, "sports."

c. Eighth abdominal tergite with one pair of large dorsal setae as large as largest on ninth tergite. Species small, not exceeding 10 mm. in length.

d. Slender, widths of pronotum about 2.51 mm.; average total length about 8.47 mm.; beak appearing long and slender; large setae of ninth tergite six or eight, usually eight. Develops in corn prop-roots, *Panicum repens*, *P. agrostoides*, timothy, *Agrostis alba*, orchard grass, bluegrass, wheat, barley, rye, *Agropyron repens*, *Elymus canadensis*, *E. robustus*, *Sitanion elymoides*, *Cyperus esculentus*, *C. strigosus*, *C. echinatus*. Occurs in Ala., Ark., Conn., D. C., Fla., Ga., Ill., Ind., Ia., Kans., Ky., Md., Mass., Mich., Minn., Miss., Mo., Neb., N. H., N. J., N. Y., N. C., O., Okla., Pa., R. I., S. C., S. D., Tex., Va., Wis. ..... **Calendra parvula**

dd. Slightly more robust, average width of pronotum (18), 2.81 mm., average total length (18), 9.02 mm.; beak appearing stocky; large setae of ninth tergite four or six, usually six. Develops in Johnson grass, oats, Bermuda grass, wheat, and barley. Occurs in Ariz. **C. phoeniciensis**

cc. Eighth abdominal tergite without large setae.

e. Setae of median and spiracular areas of pronotum and setae of mesonotum usually wanting. Develops in *Rynchospora corniculata*, *Carex crus-corvi*, *C. riparia*, *C. lupuliformis*, *C. lupulina* var. *pedunculata*, and *C. vesicaria* (?). Occurs in Ala., Ark., Ill., Kans., La., Mo. ..... **C. costicollis** var. **callosipennis**

ee. Setae of these areas not all wanting.

f. Species large, more than 11.75 mm. long. Develops in *Spartina michauxiana*, *Cyperus rotundus*, *Scirpus atrovirens*, *Carex riparia*, *and C. vesicaria* (?). Occurs in Ala., Ark., Md., Ill., Ia., Kans., Mo., Neb., and Wis. ..... **C. scoparia**

ff. Species small, less than 11.75 mm. long. Develops in timothy and bluegrass. Occurs in Ala., Calif., Conn., Del., Fla., Ill., Ind., Ia., Kans., Ky., Md., Mass., Mich., Minn., Miss., Mo., Neb., N. H., N. J., N. Y., N. C., O., Pa., R. I., S. C., Tex., Va., Wis., and Que. ..... **C. zeae**

bb. Rostrum with two tubercles caudad of the four seta-bearing tubercles.

g. Rostrum with basal pair of tubercles tall-rosetted, excrescence-like.

h. Medio-pronotal setae present. Develops in *Pontederia cordata*. Occurs in Ala., Fla., Ill., La., Md., Mass., Mich., Mo., N. J., R. I., S. C., and Tex. ..... **C. pontederiæ**

hh. Medio-pronotal setae absent.

i. Basal rostral tubercles large; space between these usually less than half the diameter of either. Develops in *Leersia oryzoides*. Occurs in Conn., D. C., Ill., Ind., Ia., Kans., Md., Mass., Mich., Minn., Mo., Neb., N. H., N. J., N. Y., O., Pa., Va., W. Va., Wis. and Ont. **C. melanocephala**

ii. Basal tubercles smaller, space between usually more than half the diameter of either. Develops in *Scirpus validus*. Occurs in Ill., Ia., Kans., Md., and Wis. **C. incongrua**

gg. Rostrum with basal pair or tubercles otherwise than above.

j. Basal pair of tubercles resembling the forward pairs. Develops in *Typha latifolia* and *Sparganium eurycarpum*. Occurs in Ala., Ariz., Calif., Col., Del., Fla., Id., Ill., Ind., Ia., Kans., La., Md., Mass., Mich., Minn., Miss., Mo., Neb., N. J., N. Y., O., Pa., S. D., Tex., Ut., Wis., Wyo., Ont. and Cuba..... **C. pertinax**

jj. Basal pair of tubercles not resembling the forward tubercles.

k. Basal pair of tubercles with three-lobed or granular bases, usually darker than rest of head; species medium or small, usually less than 13 mm. long. Develops in corn, *Panicum clandestinum*, wheat, *Cyperus schweinitzii*, *C. pseudovegetus*, *C. rotundus*, *C. esculentus*, *C. erythrorhizos*, *C. ferax*, *C. strigosus*, *C. ovularis*, *Rynchospora corniculata*, *Carex riparia*, *C. lupuliformis*, and *Juncus torreyi*. Occurs in Ala., Ariz., Ark., Fla., Ga., Ill., Ind., Ia., Kans., La., Md., Mich., Minn., Miss., Mo., Neb., N. J., N. M., N. C., Okla., Pa., S. C., Tex., and Va..... **C. callosa**

kk. Basal tubercles scarcely recognizable as such, and on a rippled, elevated contour of the head, or appearing as a cluster of miniature tubercles; size large, usually more than 13 mm. long. (See notes under "j.") **C. pertinax**

aa. Rostrum with six or more seta-bearing tubercles.

l. Rostrum with more than six seta-bearing tubercles.

m. Seta-bearing tubercles in excess of standard six, two or four, appropriately spaced for regular series, sometimes with additional seta-bearing tubercles promiscuously placed. Two medio-pronotal setae usually present.

n. Medio-pronotals two, merged with prolatero-pronotals. Length, 11.66 to 19 mm., average (8), 17.26 mm. Develops in *Scirpus validus*. Occurs in Cal. and Ore..... **C. discolor**

nn. Medio-pronotals two, in normal position. Length, 11.65 mm. to 15.63 mm., average (18), 13.52 mm. Develops in *Scirpus validus*. Occurs in Col., Ill., Ind., Ia., Kans., Mich., Minn., Mo., Neb., N. J., O., Ut., Wash., and Wis..... **C. robusta**

mm. Seta-bearing tubercles in excess of standard six, one to ten, promiscuously placed.

o. Usually four medio-pronotal setae; length, 11.11 to 18 mm., average (30), 14.05 mm. Develops in corn and *Tripsacum dactyloides*. Occurs in Ala., Kans., La., Mass. (?), Mich. (?), Okla., S. C., Tex., and Wash. (?)..... **C. maidis**

oo. Two large medio-pronotal setae; spiraculo-pronotal setae, two large and one small on each side; all setae barbed; length, 7.81 to 8.25 mm., average (2), 8.03 mm.; pronotal width, 2.78 to 2.98 mm., average, 2.88 mm. Develops in Bermuda grass. Occurs in Ala., Fla., Md., Minn., N. J., N. Y., Pa., and S. C..... **C. inaequalis**

ll. Rostrum with six seta-bearing tubercles only.

p. Rostral tubercles all conical, basal pair set on broad, irregular prominences.

q. Prominences high, deeply wrinkled.

r. Sides of prominences rounded; mesonotal setae usually four or more, sometimes two.

s. Medio-pronotal usually four, spiraculo-pronotal setae usually four, rarely wanting. (See notes under "o.") **C. maidis**

ss. Medio-pronotal setae rarely more than two, occasionally wanting.

t. Medio-pronotal setae never more than two, occasionally wanting.

u. Length, 14.77 to 23 mm., average (12) 18.49 mm.; pronotal width, 4.36 to 6.49 mm., average, 5.73 mm. Develops in *Scirpus validus* and *S. fluviatilis*. Occurs in Ala., Cal., Col., Conn., D. C., Fla., Ill., Ind., Ia., Kans., Ky., La., Mich., Minn., Mo., Neb., N. J., N. Y., N. D., O., Okla., Pa., S. D., Tex., Va., Wash., Wis., Ont., and Alberta..... **C. aequalis**

uu. Length, 11.65 to 15.63 mm., average (18), 13.52 mm.; pronotal width, 3.11 to 4.64 mm., average, 3.82 mm. (See notes under "nn.") **C. robusta**

tt. Medio-pronotal setae usually wanting, but may be two or four; length, 9.10 to 14.78 mm., average (43), 11.09 mm.; pronotal width, 2.30 to 4.22 mm., average, 3.27 mm. Develops in *Scirpus validus* and *Carex comosa*. Occurs in Calif., Col., Conn., D. C., Ida., Ill., Ind., Ia., Kans., Ky., La., Me., Mass., Mich., Minn., Miss., Mo., Neb., N. H., N. J., N. Y., N. C., N. D., O., Pa., S. C., S. D., Ut., Wis., Ont., Alberta, Man., and B. C. ..... **C. costipennis**

rr. Prominences overhanging laterad.

v. Mesonotal setae two, rarely none or three; prominences of basal tubercles low-domed, areas oval.

w. Length, 13.75 to 18.50 mm., average (2), 16.12 mm.; pronotal width, 3.79 to 4.75 mm., average, 4.27 mm. Develops in *Zizaniopsis miliacea*. Occurs in Ala., Fla., La., Miss., Mo., and Tex. ..... **C. ludoviciana**

ww. Length, 8.31 to 17 mm., average (10) 12.49 mm.; pronotal width, 2.66 to 4.40 mm., average, 3.55 mm. Develops in *Cyperus pseudovegetus*, *C. rotundus*, *C. esculentus*, *C. erythrorhizos*, *C. ferax*, *C. strigosus*, *Scirpus validus*, *S. atrovirens*, *S. eriophorum*, and *Rynchospora corniculata*. Occurs in Ala., Conn., Fla., Ill., Kans., La., Mass., Mich., Miss., Mo., Neb., N. J., N. Y., N. C., O., Pa., S. C., and Tex. ..... **C. cariosa**

vv. Mesonotal setae four; basal tubercles in their entirety appearing as hemispheres cut under at outer edge or circular with high vertical boundaries. Develops in *Spartina cynosuroides*, chiefly below high tide. Occurs in Conn., Fla., Md., Mass., N. J., N. Y., and R. I. **C. setiger**

qq. Prominences of basal tubercles moderately high, moderately wrinkled.

x. Prominences broad.

y. Species small, less than 12 mm. in average length.

z. Length, 9.10 to 14.78 mm., average (43), 11.09 mm.; pronotal width, 2.30 to 4.22 mm., average, 3.27 mm. (See notes under "tt.") ..... **C. costipennis**

zz. Length, 7.81 to 8.25 mm., average (2), 8.03 mm.; pronotal width, 2.78 to 2.98 mm., average, 2.88 mm. (See notes under "oo.") ..... **C. inaequalis**

yy. Species large, more than 12 mm. in average length.

a′. Two or more setae on eighth abdominal tergite; no spiraculo-pronotal and never more than two medio-pronotal setae. (See notes under "n.") ..... **C. discolor**

aa′. Setae on eighth tergite very small or wanting; four medio-pronotal and four spiraculo-pronotal setae usually present. (See notes under "o.") ..... **C. maidis**

xx. Prominences relatively narrow; species usually medium or small, rarely more than 13 mm. long.

b′. Prominences darker than head, three-lobed or granular. (See notes under "k.") ..... **C. callosa**

bb′. Prominences not darker than rest of head; base wrinkled, not appearing lobed or granular. (See notes under "ww.") ..... **C. cariosa**

pp. Rostral tubercles conical, basal pair not on broad, irregular prominences.

c′. Pupae less than 9.25 mm. long.

d′. Outer postlatero-pronotal seta much nearer to upper spiraculo-pronotal seta than to inner postlatero-pronotal seta. Upper spiraculo-pronotal seta much nearer to outer postlatero-pronotal seta than to lower spiraculo-pronotal seta. Develops in timothy. Occurs in Ariz., Kans., La., Md., Mich., Miss., N. M., N. C., Tex., and Wis. **C. oblita**

dd′. Outer postlatero-pronotal seta much nearer to inner postlatero-pronotal seta than to either spiraculo-pronotal seta. Upper spiraculo-pronotal seta much nearer to lower than to either postlatero-pronotal seta. Develops in *Typha latifolia*, rice, *Leersia oryzoides*, timothy, *Agrostis alba*, orchard grass, *Glyceria nervata*, wheat, *Agropyron repens*, *Elymus virginicus*, *E. canadensis* (?), *E. striatus*, and *Hystrix patula*. Occurs in Ala., Ark., Fla., Ill., Ind., Ia., Kans., Ky., La., Md., Mass., Mich., Mo., Neb., N. J., N. Y., O., Pa., S. C., and Va. ..... **C. minima**

cc′. Pupae 9.25 mm. long or longer.

e′. Mesonotal setae wanting.

f′. Total length, 11.86 to 15.37 mm., average (13), 13.65 mm.; pronotal width, 3.50 to 4.71 mm., average, 4.04 mm. (See notes under "f.") ..... **C. scoparia**

ff′. Total length, 9.22 to 12.75 mm., average (68), 10.81 mm.; pronotal width, 2.32 to 3.79 mm., average, 3.05 mm. Develops in timothy, Bermuda grass, wheat, *Cyperus esculentus* and *Scirpus validus*. Occurs in Ala., Ariz., Ark., Calif., Col., Conn., Del., Fla., Ga., Ill., Ind., Ia., Kans., Ky., La., Md., Mass., Mich., Minn., Miss., Mo., Mont., Neb., N. H., N. J., N. Y., N. C., O., Okla., Ore., Pa., R. I., S. C., Tex., Va., Wis., Wyo., and Ont. ..... **C. venatus**

ee′. Mesonotal setae present.

g′. Setae of the eighth tergite wanting. (See notes under "u.") ..... **C. aequalis**

gg′. Setae of eighth tergite present; mesonotal and metanotal setae each one or more pairs.

h′. Setae visible on eighth tergite, one pair large, dorsal, rarely irregular; no small setae. Develops in *Panicum repens*. Occurs in Ala., Fla., Mass., N. J., N. Y., N. C., Pa., and S. C. ..... **C. retusa**

hh′. Setae visible on eighth tergite, two or more pairs, rarely less, one pair being large, dorsal.

i′. Mesonotal and metanotal setae two each, rarely more. Develops in timothy, wheat, *Cyperus esculentus*, *Juncus torreyi* and *J. acuminatus*. Occurs in Ala., Ark., Ill., Ind., Ia., Kans., Md., Mich., Miss., Mo., Neb., N. J., Okla., Pa., S. C., Tex., and Can. ..... **C. destructor**

ii′. Mesonotal and metanotal setae four or six each, usually four, very rarely two, each. (See notes under "ff′."), **C. venatus**

Calendra-Progeny Host-plant List.

The plants included in this list are those species from which *Calendra* eggs, larvæ, pupæ, and new adults within the pupa cell have been collected, either within the tissue of the plant or in such close approximation to the definite larval excavation and exit hole as to leave no uncertainty as to the correctness of the relationship of the insect and its host plant.

Many collections were made in plants too immature or too old to permit of satisfactory determination. In some cases, return trips have been made to points of collection and determinable stages of growth of the plant then believed to be the same species and the same stand as that from which the collection was made, have been collected. Sometimes, the process of examining the plants for contained immature stages automatically destroyed the plant for determination.

Determinations have been secured generally from well qualified botanists, frequently after the writer has made a provisional determination, in his effort to know the billbug host plants in the field. Errors that may appear in determinations of host plants, if any appear, will be chiefly the error of the writer in discriminating between the host plant and similar plants in close proximity in the field.

The species of *Calendra* are given according to the Catalogue of Coleoptera of America, North of Mexico, by Leng.

Group A.

Calendra inaequalis, Uneven Billbug.
Cynodon dactylon, Bermuda Grass.

Group B.

Calendra aequalis, Clay-colored Billbug.
Zea mays, Corn. *Scirpus validus*, Am. Great Bulrush; Mat-rush; Tule. **Scirpus fluviatilis*, River Bulrush.

Calendra discolor, Tule Billbug.
Scirpus validus.

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*Those plants marked with the asterisk are, in each case, the preeminent host plants for the particular billbug under consideration, in the opinion of the writer.

GROUP C.

Calendra pertinax, Cat-tail Billbug.

**Typha latifolia*, Common Cat-tail, Broad-leafed Cat-tail. *Sparganium eurycarpum*, Broad-fruited Bur-reed.

Calendra setiger, Low-tide Billbug.

**Spartina cynosuroides*, Salt Reed-grass.

Calendra ludoviciana, Knife-flag Billbug.

**Zizaniopsis miliacea*, Knife-flag, Zizaniopsis.

Calendra robusta, Robust Billbug.

**Scirpus validus*.

Calendra costipennis, Rib-winged Billbug.

**Scirpus validus*. *Carex comosa*, Bristly Sedge.

Calendra costicollis v. **callosipennis,** Lake-bank Sedge Billbug.

Rhyncospora corniculata, Beaked Rush. *Carex crus-corvi*, Raven's-foot Sedge. **Carex riparia*, Lake-bank Sedge. *Carex lupuliformis*, Hop-like Sedge. *Carex lupulina*, v. *pedunculata*, Hop Sedge. *Carex vesicaria*, Inflated Sedge, (?).

Calendra maidis, Maize Billbug.

Zea mays, Corn. **Tripsacum dactyloides*, Gama or Sesame Grass.

Calendra cariosa, Beaked-rush Billbug.

Cyperus pseudovegetus, Marsh Cyperus. *Cyperus rotundus*, Nut-grass, Coco-grass. *Cyperus esculentus*, Yellow Nut-grass, (?). *Cyperus erythrorhizos*, Red-rooted Cyperus. *Cyperus ferax*, Coarse Cyperus. *Cyperus strigosus*, Straw-colored Cyperus. *Scirpus validus*. *Scirpus atrovirens*, Dark-green Bulrush. *Scirpus eriophorum*, Wool-grass. **Rhynchospora corniculata*, Beaked Rush.

GROUP D.

Calendra parvula, Bluegrass Billbug.

Zea mays, Corn (Prop-roots). *Panicum repens*, Creeping Panic. *Panicum agrostoides*, Red-top Panic. *Phleum pratense*, Timothy. *Agrostis alba*, Fiorin; White Bent-grass; Red-top. *Dactylus glomeratus*, Orchard Grass. **Poa pratensis*, Kentucky Blue-grass. *Triticum sativum*, Wheat. *Agropyron repens*, Couch-grass; Quitch-grass; Quack Grass. *Hordeum sativum*, Barley. *Hordeum jubatum*, Squirrel-tail Grass. *Secale cereale*, Rye. *Elymus canadensis*, Nodding Wild Rye; Canadian Lyme-grass. *Elymus robustus*, Robust Wild Rye. *Sitanion elymoides*, Long-bristled Wild Rye. *Cyperus esculentus*. *Cyperus strigosus*. *Cyperus echinatus*, Echinate Sedge.

Calendra minima, Terrell-grass Billbug.

Typha latifolia. Oryza sativa, Rice. *Leersia oryzoides,* Rice Cut-grass. *Phleum pratense,* Timothy. **Agrostis alba. Dactylus glomeratus. Glyceria nervata,* Meadow Grass; Nerved Manna-grass. *Triticum sativum,* Wheat. *Agropyron repens. **Elymus virginicus,* Terrell-grass; Virginia Wild Rye. *Elymus canadensis,* (?) *Elymus striatus,* Slender Wild Rye. *Hystrix patula,* Bottle-brush Grass.

Calendra retusa, Creeping Panic Billbug.

**Panicum repens.*

Calendra destructor, Destructive Billbug.

*Phleum pratense. Triticum sativum. *Cyperus esculentus. Juncus torreyi,* Torrey's Rush. *Juncus acuminatus,* Sharp-fruited Rush.

Calendra zeæ, Timothy Billbug.

**Phleum pratense. Poa pratensis.*

Calendra scoparia, Tall Marsh-grass Billbug.

Spartina michauxiana, Tall Marsh Grass. *Cyperus rotundus,* (?) *Scirpus atrovirens. *Carex riparia. Carex vesicaria,* (?)

Calendra callosa, Curlew Billbug.

Zea mays, Corn. *Panicum clandestinum,* Corn Grass; Deer-tongue Grass. *Triticum sativum. Cyperus schweinitzii,* Schweinitz's Cyperus. *Cyperus pseudovegetus. Cyperus rotundus. *Cyperus esculentus. Cyperus erythrorhizos. Cyperus ferax. Cyperus strigosus. Cyperus ovularis,* Globose Cyperus. *Rynchospora corniculata. Carex riparia. Carex lupuliformis. Juncus torreyi.*

Calendra melanocephala, Cut-grass Billbug.

**Leersia oryzoides.*

Calendra pontederiæ, Pickerel-weed Billbug.

**Pontederia cordata,* Pickerel-weed.

Calendra venatus, Hunting Billbug.

*Phleum pratense. Cynodon dactylon. Triticum sativum. *Cyperus esculentus. Scirpus validus.*

Calendra phoeniciensis, Phoenix Billbug.

Sorghum halipense, Johnson Grass. *Avena sativa,* Oats. **Cynodon dactylon. Triticum sativum. Hordeum sativum.*

Calendra incongrua, Incongruous Billbug.

**Scirpus validus.*

Calendra oblita, Oblite Billbug.

Phleum pratense.

Host-Plant Calendra-Progeny List.

TYPHACEÆ (Cat-tail Family).

Typha latifolia, Common Cat-tail.
Calendra pertinax, Cat-tail Billbug. *Calendra minima,* Terrell-grass Billbug.

SPARGANIACEÆ (Bur-Reed Family).

Sparganium eurycarpum, Broad-fruited Bur-reed.
Calendra pertinax.

GRAMINEÆ (Grass Family).

Zea mays, Corn.
Calendra aequalis, Clay-colored Billbug. *Calendra callosa,* Curlew Billbug. *Calendra maidis,* Maize Billbug. In Corn Prop-roots: *Calendra parvula,* Bluegrass Billbug.

Tripsacum dactyloides, Gama or Sesame Grass.
Calendra maidis.

Sorghum halepense, Johnson Grass.
Calendra phoeniciensis, Phoenix Billbug.

Panicum repens, Creeping Panic.
Calendra retusa, Creeping Panic Billbug. *Calendra parvula.*

Panicum agrostoides, Munro Grass.
Calendra parvula.

Panicum clandestinum, Corn Grass; Deer-tongue Grass.
Calendra callosa.

Oryza sativa, Rice.
Calendra minima.

Zizaniopsis miliacea, Knife-flag; Zizaniopsis.
Calendra ludoviciana, Knife-flag Billbug.

Leersia oryzoides, Rice Cut-grass.
Calendra melanocephala, Cut-grass Billbug. *Calendra minima.*

Phleum pratense, Timothy.
Calendra destructor, Destructive Billbug. *Calendra minima. Calendra oblita,* Oblite Billbug. *Calendra parvula. Calendra venatus,* Hunting Billbug. *Calendra zeae,* Timothy Billbug.

Agrostis alba, Fiorin; White Bent-grass; Red-top.
Calendra parvula. Calendra minima.

Avena sativa, Oats.
Calendra phoeniciensis.

Spartina michauxiana, Tall Marsh Grass.
Calendra scoparia, Tall Marsh Grass Billbug.

Spartina cynosuroides, Salt Reed-grass.
Calendra setiger, Low-tide Billbug.

Cynodon dactylon, Bermuda Grass.
Calendra inaequalis, Uneven Billbug. *Calendra phoeniciensis. Calendra venatus.*

Dactylus glomeratus, Orchard Grass.
Calendra parvula. Calendra minima.

Poa pratensis, Kentucky Bluegrass.
Calendra parvula. Calendra zeae.

Glyceria nervata, Meadow Grass; Nerved Manna Grass.
Calendra minima.

Triticum sativum, Wheat.
Calendra parvula. Calendra minima. Calendra destructor. Calendra callosa. Calendra venatus. Calendra phoeniciensis.

Agropyron repens, Couch Grass; Quitch Grass; Quack Grass.
Calendra parvula. Calendra minima.

Hordeum sativum, Barley.
Calendra parvula. Calendra phoeniciensis.

Hordeum jubatum, Squirrel-tail Grass.
Calendra parvula.

Secale cereale, Rye.
Calendra parvula.

Elymus virginicus, Terrell Grass; Virginia Wild Rye.
Calendra minima.

Elymus canadensis, Nodding Wild Rye, Canada Lyme-grass.
Calendra parvula. Calendra minima, (?)

Elymus robustus, Robust Wild Rye.
Calendra parvula.

Elymus striatus, Slender Wild Rye.
Calendra minima.

Sitanion elymoides, Long-bristled Wild Rye.
Calendra parvula.

Hystrix patula, Bottle-brush Grass.
Calendra minima.

CYPERACEÆ (Sedge Family).

Cyperus schweinitzii, Schweinitz's Cyperus.
Calendra callosa.

Cyperus pseudovegetus, Marsh Cyperus.
Calendra cariosa, Beaked-rush Billbug. *Calendra callosa.*

Cyperus rotundus, Nut Grass; Coco Grass.
Calendra cariosa. Calendra scoparia, (?) *Calendra callosa.*

Cyperus esculentus, Yellow Nut-grass.
Calendra cariosa. Calendra parvula. Calendra destructor. Calendra callosa. Calendra venatus.

Cyperus erythrorhizos, Red-rooted Cyperus.
Calendra cariosa. Calendra callosa.

Cyperus ferax, Coarse Cyperus.
Calendra cariosa. Calendra callosa.

Cyperus strigosus, Straw-solored Cyperus.
Calendra cariosa. Calendra parvula. Calendra callosa.

Cyperus ovularis, Globose Cyperus.
Calendra callosa.

Cyperus echinatus, Echinate Cyperus.
Calendra parvula.

Scirpus validus, American Great Bulrush; Mat-rush; Tule.
Calendra aequalis. Calendra cariosa. Calendra costipennis, Rib-Winged Billbug. *Calendra discolor,* Tule Billbug. *Calendra incongrua,* Incongruous Billbug. *Calendra robusta,* Robust Billbug. *Calendra venatus.*

Scirpus fluviatilis, River Bulrush.
Calendra aequalis.

Scirpus atrovirens, Dark-green Bulrush.
Calendra cariosa. Calendra scoparia.

Scirpus eriophorum, Wool-grass.
Calendra cariosa.

Rynchospora corniculata, Beaked Rush.
Calendra costicollis v. *callosipennis,* Lake-bank Sedge Billbug. *Calendra cariosa. Calendra callosa.*

Carex crus-corvi, Raven's Foot Sedge.
Calendra costicollis v. *callosipennis.*

Carex riparia, Lake-bank Sedge.
Calendra costicollis v. *callosipennis. Calendra scoparia. Calendra callosa.*

Carex comosa, Bristly Sedge.
Calendra costipennis.

Carex lupuliformis, Hop-like Sedge.
Calendra callosa.

Carex lupulina var. **pedunculata,** Hop Sedge.
Calendra costicollis v. *callosipennis.*

Carex vesicaria, Inflated Sedge. (?).
Calendra costicollis ver. *callosipennis. Calendra scoparia.*

PONTEDERIACEÆ (Pickerel-Weed Family).

Pontederia cordata, Pickerel-weed.
Calendra pontederiæ, Pickerel-weed Billbug.

JUNCACEÆ (Rush Family).

Juncus torreyi, Torrey's Rush.
Calendra destructor. Calendra callosa.

Juncus acuminatus, Sharp-fruited Rush.
Calendra destructor.

EXPLANATION OF PLATES.

Plate I.

Figs. 1–4. *Calendra aequalis*. 1, Male, dorsal view, with two prolatero-pronotal setæ, four postlatero-pronotals, two medio-pronotals, spiraculo-pronotals (not shown), six mesonotals, and four metanotals. Formula: 2.4.2.?.6.4. 2, Ventral view of same pupa. Rostral setæ 6. Setæ of tergite 8 wanting. 3, Lateral view of female. Setal formula: 4.4.2.0.4.4. Setæ of tergite 8 wanting. 4, Ventral view of same female. Rostral setæ 6. Setæ of tergite 8 wanting. Compare anal pattern with that of male.

Figs. 5–7. *C. discolor*. 5, Male, dorsal view. Setal formula: 6.4.0.?.6.4, or 4.4.2.?.6.4, the medio-pronotals having migrated to the prolatero-pronotal groups. 6, Lateral view of same pupa. Rostral setæ, 8. Setæ of tergite 8, 2, small. 7, Caudal end of abdomen, segments 7–10. Male type. Setæ of tergite 8, 2, small.

Figs. 8–9. *C. pertinax*. 8, Female, lateral view. Rostral setæ, 4; tubercles, 6; setæ of tergite 8, 0. 9, Head of same female.

Figs. 10–12. *C. ludoviciana*. 10, Female, lateral view. Rostrum with 6 setæ, basals on prominences overhanging laterad. Setal formula: 2.4.?.4.?.?. 11, Anal view of same female. Setæ of tergite 8, 2, small. 12, Anal view of male.

Figs. 13–15. *C. costicollis* var. *callosipennis*. Male. 13, Dorsal view. Setal formula: 0.4.0.?.0.2. 14, Thorax, lateral view, same pupa. Only 4 tubercles, each seta-bearing. No spiraculo-pronotal setæ. 15, Lateral view of caudal end, no setæ on tergite 8.

Plate II.

Figs. 16–17. *C. maidis*. 16, Female, lateral view. Setal formula: 4.4.4.?.2 or 6.4. Rostrum, 6 setæ. Tergite 8, 0. 17, Dorsal view of same pupa: 4.4.4.?.6.4.

Figs. 18a–18b. *C. cariosa*. 18a, Female, dorsal view. 18b, Same pupa, ventral view.

Figs. 19a–19b. *C. cariosa*. 19a, Male, ventral view. Rostrum, 6 setæ. Tergite 8, 0. Fig. 19b, Lateral view.

Figs. 20–22. *C. parvula*. 20, Male, lateral view. Rostrum, 4 tubercles only, each seta-bearing. Setæ of tergite 8, 2, large as largest on tergite 9. 21, Ventral view, same pupa. 22, Dorsal view of thorax of female. Setal formula: 4.4.0.?.0.0.

Figs. 23–24. *C. minima*. Female. 23, Lateral view, rostrum with 6 setæ. Formula: 4.4.2.4.2.2. Setæ of tergite 8, 2, large. 24, Caudal view, same female.

Figs. 25–26. *C. retusa*. Female. 25, Dorsal view. Formula: 4.4.2.4.2.2. Setæ of tergite 8, 2, large. 26, Ventral view of same female. Rostral setæ, 6.

Plate III.

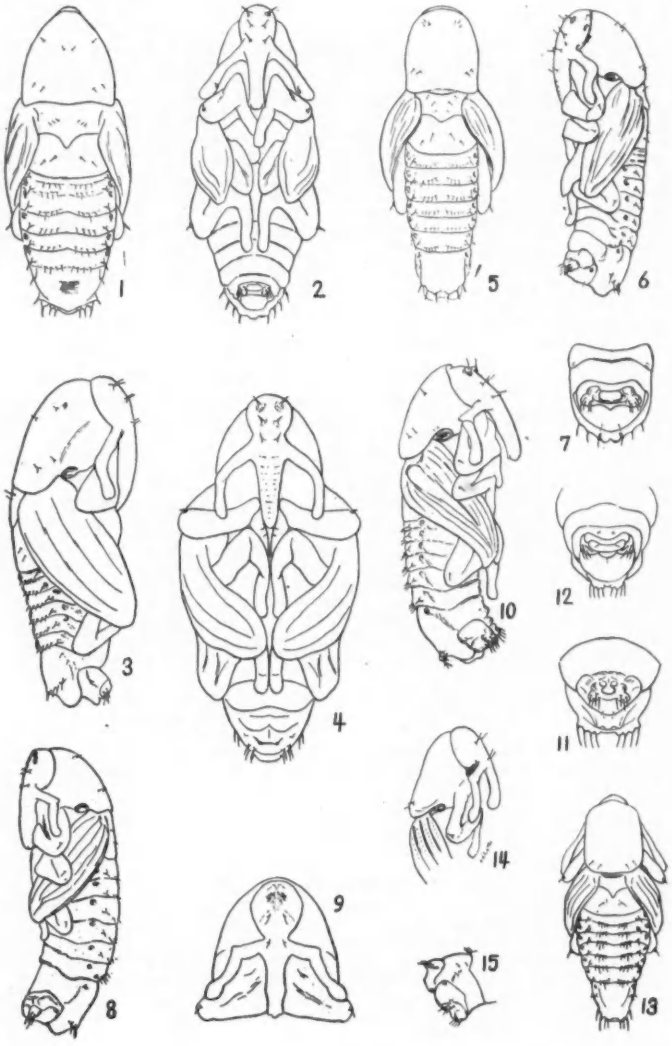
Figs. 27–30. *C. destructor*. Female. 27, Dorsal view. Formula: 4.4.2.4.2.2. 28, Lateral view; rostrum with 6 setæ; tergite 8, 2, large, 6 small setæ. 29, Ventral view. 30, Caudal end.

Figs. 31–33. *C. scoparia*. 31, Female, dorsal view. Formula: 4.4.0.4.0.2. 32, Same pupa, ventral view, 4 rostral setæ, 4 rostral tubercles only. 33, Caudal end, no setæ on tergite 8.

Figs. 34–36. *C. callosa*. 34, Dorsal view. Formula: 4.4.0.?.0.2. 35, Ventral view, same female. Rostrum with 6 setæ, basals small, on granular or excrescence-like prominences darker than head. 36, Male, ventral view.

Figs. 37–41. *C. melanocephala*. 37, Female, ventral view, rostrum with 6 tubercles, basals tall-rosetted, excrescence-like, without setæ; tergite 8 without setæ. 38, Dorsum of thorax, male. Formula: 0.4.0.?.0.4. 39, Caudal end of same male. 40, Lateral view. 41, Ventral view, same male.

Figs. 42–43. *C. venatus*. Female. 42, Dorsal view. Formula: 4.4.2.4.4.4. Setæ of tergite 8, 2, large. 43, Same pupa, lateral view. Rostrum with 6 regular setæ.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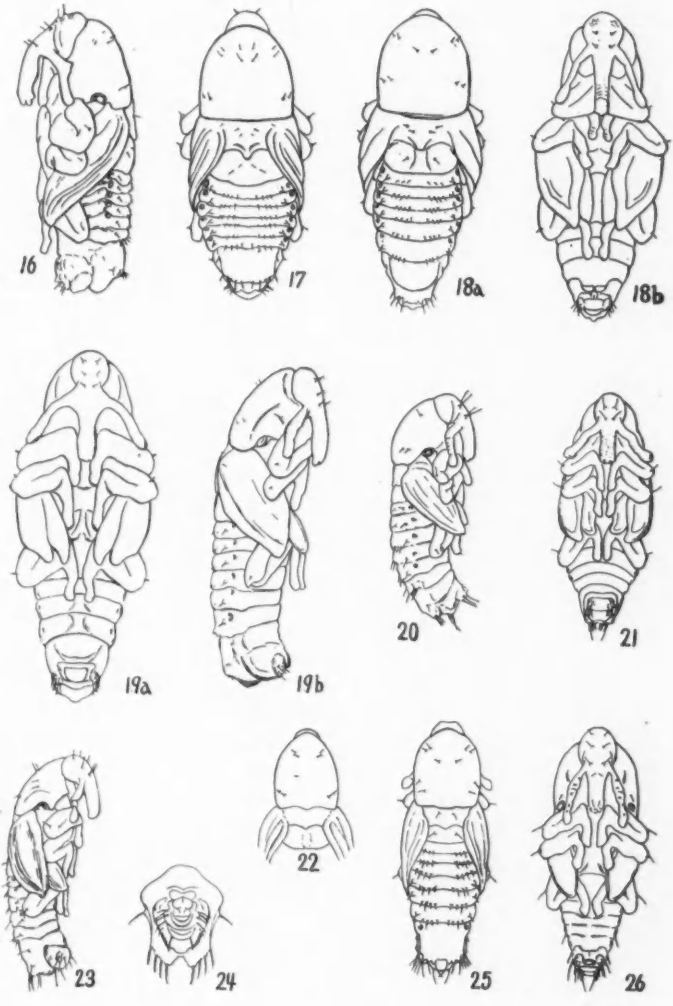
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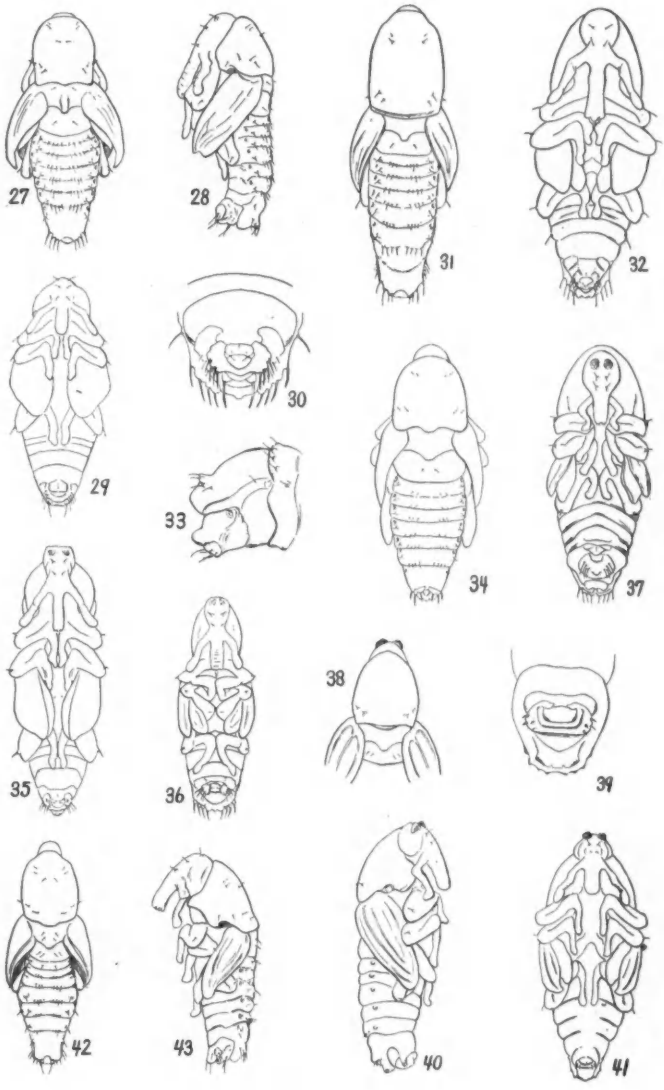
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ADDITIONS AND CORRECTIONS TO LINDSEY'S "TYPES OF HESPERIOID GENERA."

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In 1925, A. W. Lindsey* published a list of the Hesperioid genera and their types. The object of his catalog was to bring together a complete list of generic names that have been used in the family and to fix their genotypes by the International Rules of Zoological Nomenclature. Five hundred and seventy-four generic names were included by Lindsey in his list. Twenty-five additional ones have been found or have been proposed since its appearance. Naturally in a list of this size some omissions and errors are bound to occur. It has seemed advisable to bring the list up to date, including whatever corrections that could be made in the original one. The form used by Lindsey has been followed for the sake of uniformity.

Acknowledgment is due Dr. William Schaus for access to his library kindly given, and to Dr. A. W. Lindsey and Mr. R. C. Williams for their critical notes and remarks relative to the material presented herewith.

Preoccupied names are marked ‡.

Abantis Haplotype *Abantis tettensis* Hopff.

1855, Hopff., Verh. Akad. Wissensch. Berl. 643.
1875, Scudder, Hist. Sk. 99. Cites *tettensis* as type (sole species).

Aguna Orthotype *Eudamus camagura* Williams.

1927, Williams, Trans. Am. Ent. Soc. 53, 286. Cites *camagura* as type.

‡Anaperus Diatype *Eudamus caicus* H.-S.

1919, Mabille and Boullet, Ann. Sci. Nat., Zool. (x), 2, 232. Preoccupied by *Anaperus* Trosch., Ech., 1846, and by *Anaperus* v. Graffe, Verm., 1911. *Phoedinus* G. & S., which *Anaperus* M. & B. was to replace, is not preoccupied; apparently the spelling has been confused with that of *Phaedinus* Serv., Coleop., 1834.

Autochton Haplotype *Autochton itylus* Hbn.

1823, Hübner, Zütrage Exot. Schmett., fig. 249–250. Sole species, *itylus*. If *itylus* is congeneric with *Cecropterus* species as it is given by Watson, Mabille, and Draudt, the latter genus, *Cecropterus* H.-S., 1869 (type *zarex* Hbn. = *aunus* Fabr.), must fall.

*Lindsey, Ann. Ent. Soc. Am., XVIII, 75–106, 1925.

Brachycneme

1869, Herrich-Schaeffer, Corr.-Blatt. Regensb. 23, 138. In "Analyt. Table Genera"; no species given; also see p. 157 (1870).

1875, Scudder, Hist. Sk. 127. Says no species cited and falls because of *Brachycnemis* Schonh., Coleop., 1844.

Scudder's second objection does not hold according to the International Rules.

‡Caecina Logotype *Caecina calathana* Hew.

1868, Hewitson, Descr. Hesp. ii, 55. *Calathana* and *compusa*.

1875, Scudder, Hist. Sk. 129. Cites *calathana* as type.

1879, Plötz, Stett. Ent. Zeit. 40, 179. Cites *compusa* as type.

1893, Watson, Proc. Zool. Soc. Lond. 1893, 19. Cites *calathana* as type. Preoccupied by *Caecina* Stal, Hemip., 1863. *Ocyba* Lindsey, 1925, Ann. Ent. Soc. Am. 18,94 erected to replace *Caecina* Hew.

Calleagris Haplotype *Eagris jamesoni* E. Sharpe.

1925, Aurivillius in Seitz, Grossschmett, 13, 571. For *jamesoni* E. Sharpe.

Camptopleura Logotype *Camptopleura theramenes* Mab.

1877, Mabille, Pet. Nouv. Ent. ii, 166.

C. iphicrates Mab., is also described in a continuation of the same article on page 197 (1878).

Carcharodus Logotype *Papilio alceæ* Esp.

1820, Hübner, Verz. bek. Schmett. 110. *Lavatheræ* (!), *altheæ*, *alceæ* and *malvæ*.

1879, Plötz, Stett. Ent. Zeit. 40, 179. Cites *alceæ* Esp. as type.

1893, Watson, Proc. Zool. Soc. Lond. 1893, 44. Cites *lavateræ* as type.

1925, Lindsey, Ann. Ent. Soc. Am. 18, 81. Confirms *lavateræ* as type.

The type designations by Plötz in 1879 apparently were overlooked by Lindsey.

Chaetocneme Logotype *Chaetocneme corvus* Feld.

1860, Felder, Sitzungsb. Acad. Wien xl, 460. *Corvus* and *cerinthus*, no type being cited.

1870, Butler, Ent. Mon. Mag. vii, 57. Cites *corvus* as type.

Corythaeolos

1904, Mabille in Wytsman, Gen. Ins., Hesp. 105. Cites this generic name with the reference "Watson, Class. Hesp. p. 77 (1893)." (=*Koruthaialos* Watson, 1893).

Elwesia Orthotype *Elwesia lesliei* Evans.

1926, Evans, Journ. Bomb. Nat. Hist. Soc. 31, 53. Cites *lesliei* Evans as type (sole species).

Eudamus (See *Goniurus*).

Eumesia Haplotype *Eumesia semiargentea* Feld.

1867, Felder, Reise Novara, 504. Sole species, *semiargentea*.

1870, Butler, Ent. Mon. Mag. vii, 96. States type is *semiargentea* Feld.

1875, Scudder, Hist. Sk. 171. Says preoccupied by *Eumesius* Westw. Hymen., 1840; but not so to be held according to the International Rules.

Goniloba Logotype *Niconiades xanthaphes* Hbn.

1852, Westwood and Hewitson, Gen. Diurn. Lep. ii, 511.

1875, Scudder, Hist. Sk. 179. *Xanthaphes* is printed in bold-faced type, which with remarks in the introduction, constitutes a type fixation by Scudder.

Goniurus Logotype *Papilio proteus* Linn.

1820, Hübner, Verz. bek. Schmett. 104. *Simplicius, coelus, proteus*, etc.
1852, Westwood and Hewitson, Gen. Diurn. Lep. ii, 510. Cite *proteus* as type.
1870, Butler, Ent. Mon. Mag. vii, 56. Pseudotype *simplicious* Stoll.
1875, Scudder, Hist. Sk. 180. Pseudotype *coelus* Cram.
1879, Plötz, Stett. Ent. Zeit. 40, 178. Correctly cites *proteus* as type.
1893, Watson, Proc. Zool. Soc. Lond. 20. Pseudotype *coelus* Cram.
1916, Barnes & McDunnough, Contrib. iii, 2. Pseudotype *simplicius*.
1922, Skinner & Williams, Trans. Am. Ent. Soc. 48, 115. Again cite *coelus* as type.
1925, Lindsey, Ann. Ent. Soc. Am. 18, 98. Pseudotype *simplicius* Stoll.
1929, Shepard, Ent. News 40, 233. *Proteus* cited as true type. *Eudamus* Swain. with type *proteus* becomes a synonym of *Goniurus* Hbn.

Halpe Logotype *Halpe beturia* Moore.

1878, Moore, Proc. Zool. Soc. Lond. 689. *Beturia, ceylonica* and others.
1893, Watson, Proc. Zool. Soc. Lond. 93. Cites *beturia* as type.
1925, Lindsey, Ann. Ent. Soc. Am. 18, 88. Pseudotype *ceylonica*. Zoo. Record for 1878 mentions five included species, but does not cite a type.

Hewitsonia Orthotype *Eudamus aenesius* Hew.

1926, Evans, Journ. Bomb. Nat. Hist. Soc. 31, 50. Cites *aenesius* as type. Preoccupied by *Hewitsonia* Kirby, Lycaenidæ, 1871. See *Hewitsoniella*.

Hewitsoniella Diatype *Eudamus aenesius* Hew.

New name for *Hewitsonia* Evans, preoccupied.

Mimambrix Haplotype *Mimambrix woolletti* Riley.

1923, Riley, Entomologist 56, 37. *Woolletti* Riley, sole species.

Mooreana Orthotype *Pterygospidea trichoneura* Feld.

1926, Evans, Journ. Bomb. Nat. Hist. Soc, 31, 51. Cites *trichoneura* Feld. as type.

Nicevillea Orthotype *Pamphila gola* Moore.

1926, Evans, Journ. Bomb. Nat. Hist. Soc. 31, 57 and 623. Cites *gola* as type.

Orthophaetus Diatype *Eudamus phanaeus* Hew.

1895, Watson, Journ. Bomb. Nat. Hist. Soc. 9, 419 and 422. Not spelled *Orthophoetus*. New name for *Pteroxys* Watson, which see.

Paronymus Logotype *Hesperia ligora* Hew.

1925, Aurivillius in Seitz. Grossschmett 13, 520. For six species including *ligora* Hew., which may be taken as genotype.

Pellicia Logotype *Pellicia dimidiata* H.-S.

1870, Herrich-Schæffer, Corr.-Blatt Regensb. 159, referring the genus to Plötz.
1875, Scudder, Hist. Sk. 243. Cites *dimidiatus* as type.
1879, Plötz, Stett. Ent. Zeit. 40, 176 and 179. Uses *Pellicia* n. g. and cites *macarus* H.-S. as type.

Pereneia Orthotype *Pereneia pandora* Lindsey.

1925, Lindsey, Denison Univ. Bull. 25, 107. One species, *pandora*.

Pithauriopsis Logotype *Pithauriopsis aitchisoni* W.-M. & de Nicev.

1886, Wood-Mason and de Niceville, Journ. Asiat. Soc. Bengal, 4, 387. Describe *aitchisoni* and *stramineipennis*.
1925, Lindsey, Ann. Ent. Soc. Am. 18, 97. Gives *aitchisoni* as "haplotype;" of the *two* new species originally described in this genus, *aitchisoni*, designated by Lindsey, may be considered logotype.

Pola Orthotype *Ismene ataphus* Wats.

1912, Swinhoe, Lep. Ind. ix, 226. Date and page incorrect in Lindsey's article.

‡**Pteroxys** Orthotype *Eudamus phanaeus* Hew.

1893, Watson, Proc. Zool. Soc. Lond. 29.
1895, Watson, Journ. Bomb. Nat. Hist. Soc. 9, 419. Gives new name *Orthophaetus*, *Pteroxys* Watson being preoccupied by *Pteroxys* Hampson, 1893, Psychidæ. See *Orthophaetus*.

‡**Ramburia** Orthotype *Pyrgus antonia* Speyer.

1926, Warren, Trans. Ent. Soc. Lond. 14. Cites *antonia* Speyer as type. Preoccupied by *Ramburia* Desv., Diptera, 1851. See *Warrenohesperia*.

Reverdinia Orthotype *Pyrgus staudingeri* Speyer.

1926, Warren, Trans. Ent. Soc. Lond. 14. Cites *staudingeri* as type.

Reverdinus Logotype *Carcharodus altheæ* Hbn.

1919, Ragusa, Naturalista Sicil. 23, 172. Includes *altheæ* Hbn., *baeticus* Ramb. and *floccifera* Zell., but does not cite a type.
1925, Lindsey, Ann. Ent. Soc. Am. 18, 100. Cites *altheæ* as type.

Sartora Orthotype *Ismene ionis* de Nicev.

1912, Swinhoe, Lep. Ind. ix, 229.

Scelotrix (not Scelothrix) Logotype *Scelotrix carthami* Ramb.

1858, Rambur, Cat. Lep. Andal. i, 63.
1879, Plötz, Stett. Ent. Zeit. 40, 179. Cites *sidæ* as type, but *sidæ* is not given by Rambur in the original article.
1893, Watson, Proc. Zool. Soc. Lond. 65. Cites *carthami*, Rambur's first species, as type.
1916, Barnes and McDunnough, Contrib. iii, 121. Pseudotype *malvæ*.
1925, Lindsey, Ann. Ent. Soc. Am. 18, 100. Cites *carthami*.

Seseria Orthotype *Suastus nigroguttatus* Mats.

1919, Matsumura, Thousand Insects of Japan, Addit. 3, 683.

Symmachia Diatype *Papilio comma* Linn.

1837, Sodoffsky, Bull. S. I. Mosc. 10 (7), 120. Suggested in place of *Hesperia*!

Syrichtus Logotype *Papilio sao* Bergst.

1832–3, Boisduval, Icones, 230.
1879, Plötz, Stett. Ent. Zeit. 40, 179. Cites *sao* Bergst, as type.
1879, Elwes and Edwards, Rev. Orient. Hesp. 153. Cite *proto* as type.

Tarmia Orthotype *Tarmia monastica* Lindsey.

1925, Lindsey, Denison Univ. Bull. 25, 110. One species, *monastica*.

Tmetocerus

1895, G. A. Poujade, Ann. Soc. Ent. France 64, cxliv. "*Thymele* Hbn. (ex parte)". Gives "Tmetocerus P. Mab." under which is included *asander*.

Tuttia Orthotype *Papilio tessellum* Hbn.

1926, Warren, Trans. Ent. Soc. Lond. 14. Cites *tessellum* Hbn. as type.

Warrenohesperia Diatype *Pyrgus antonia* Speyer.

1926, Strand, Arch. Naturg. 92, A8, 74. New name for *Ramburia* Warren, preoccupied.

Xanthodisca Haplotype *Astictopterus vibius* Hew.

1925, Aurivillius in Seitz, Grossschmett, 13, 528. For *vibius* Hew.

Zehala Orthotype *Ismene striata* Hew.

1912, Swinhoe, Lep. Ind. ix, 229.

NOTES ON DIGESTION IN SEVEN SPECIES OF INSECTS.*

MILLARD C. SWINGLE,
Assistant Entomologist, Bureau of Entomology,
United States Department of Agriculture.

During the spring of 1928 some experiments were performed on a number of insects to determine any differences in their abilities to digest certain classes of foods. It seemed important to determine if the specificity of the feeding habits of insects could be linked with their respective abilities to digest various classes of foods.

The specimens used for the work were dissected and a portion of the material to be tested was removed and mixed with the food to be digested in a micro-tube. Check tubes containing boiled material were incubated under the same conditions as the active tubes. All tubes were capped with toluene to prevent the entrance of micro-organisms from the air, and were then allowed to incubate for at least 48 hours at room temperature. Methods used in testing for the end-products of digestion were similar to those outlined by Hawk and Bergeim (1), and Swingle (2).

RESULTS.

TABLE I.

AMERICAN LOCUST (*Schistocerca americana*), ORDER ORTHOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED**				
	Starch	Maltose	Sucrose	Fats	Proteins
Salivary glands	+	—	—	—	—
Fore gut tissue	—	+	+	—	—
Gastric coeca	—	+	+	+	+
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	+	+	+	—	—
Mid gut contents	+	+	+	+	+
Hind gut contents	+	+	+	+	+

** "+" indicates digestion; "—" indicates no digestion; a blank space indicates that no test was made.

*Contribution No. 68. Research Laboratories, Moorestown, New Jersey.

TABLE II.

CHINESE MANTIS (*Paratenodera sinensis* Sauss.), ORDER ORTHOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Salivary glands	+	+	+	—	—
Fore gut tissue	—	+	+	—	+
Gastric coeca	—	+	+	—	—
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	+	+	+	—	+
Mid gut contents	+	+	+	+	+
Hind gut contents	—	+	+	+	+

TABLE III.

A DRAGONFLY (*Libellula luctuosa* Berm.), ORDER ODONATA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	—	+	+	—	—
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	—	+	+	+	+
Mid gut contents	—	+	+	+	+
Hind gut contents	—	+	+	+	+

TABLE IV.

SPOTTED GRAPEVINE BEETLE (*Pelidnota punctata* L.), ORDER COLEOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	—	+	+	—	—
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	—	+	+	—	—
Mid gut contents	—	+	+	+	+
Hind gut contents	—	+	+	+	+

TABLE V.

SPOTTED GRAPEVINE BEETLE (*Pelidnota punctata* L.), ORDER COLEOPTERA, LARVA.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	−	+	+	−	−
Mid gut tissue	−	+	+	+	+
Hind gut tissue	−	−	−	−	−
Fore gut contents	+	+	+	+	+
Mid gut contents	+	+	+	+	+
Hind gut contents	+	+	+	+	+

TABLE VI.

RED MILKWEED BEETLE (*Tetraopes tetraophthalmus* Forst.), ORDER COLEOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	−	+	+	−	−
Mid gut tissue	−	+	+	−	−
Hind gut tissue	−	−	−	−	−
Fore gut contents	−	+	+	−	+
Mid gut contents	−	+	+	+	+
Hind gut contents	−	+	+	+	−

TABLE VII.

PROMETHEA MOTH (*Callosamia promethea* Dru.), ORDER LEPIDOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	−	+	−	+	
Mid gut tissue	−	+	−	+	
Hind gut tissue	−	−	−	−	
Fore gut contents	−	+	−	+	
Mid gut contents	−	+	−	+	
Hind gut contents	−	+	−	−	

TABLE VIII.

A BUMBLEBEE (*Bremus ferridus* Fab.), ORDER HYMENOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Salivary glands	+	–	–	–	–
Fore gut tissue	–	+	+	–	+
Mid gut tissue	–	+	+	+	+
Hind gut tissue	–	–	–	–	–
Fore gut contents	+	+	+	–	+
Mid gut contents	+	+	+	+	+
Hind gut contents	+	+	+	+	+

SUMMARY.

Extracts were made of the various regions of the digestive tract in seven species of insects and were tested for their power of digesting five different food materials. Only slight differences in digestion were found among the different species. None of these could be linked with the great specificity of feeding habits in the insects.

Extracts of the tissue of the hind gut of each insect failed to digest any of the food materials used.

LITERATURE CITED.

(1.) **Hawk, P. B., and Bergeim, O.** Practical physiological chemistry, 9th edition, pp. 41–244, pls. 3 and 4, figs. 12A–73. P. Blakiston's Son and Company, Philadelphia. 1927.

(2.) **Swingle, H. S.** Digestive enzymes of the Oriental Fruit Moth. Annals Ent. Soc. Amer. 21: 469–475. 1928.

NEW NORTH AMERICAN SARCOPHAGIDÆ.

DAVID G. HALL,
U. S. Bureau of Entomology.

Two undescribed species of Sarcophagidæ which belong to the Chaetoravinia group have come to hand since the publication of my paper, "*Sarcophaga pallinervis* and Related Species in the Americas."* These are described below, and a key is presented to separate them from those species with which they might be confused.

1. Fourth abdominal segment and first segment of the hypopygium black.... 2
   Fourth abdominal segment partially red; first segment of the hypopygium red.... 3
2. Outer verticals present in male.... **S. latisetosa** Park.
   Outer verticals absent.... **S. stimulans** Walk.
3. Outer verticals present.... **S. laakei** n. sp.
   Outer verticals absent.... 4
4. Anterior clasper of male elongate, curved strongly forward; anterior plates of penis elongate and at right angles to stalk.... **S. effreneta** Walk.
   Anterior clasper heavy, only slightly curved forward to a blunt tip; anterior edge of clasper transparent; penis essentially as in *S. stimulans* Walk.... **S. coachellensis** n. sp.

Sarcophaga laakei n. sp.

Male: Chaetotaxy essentially as in *S. latisetosa* Parker, which has been so well described that there is no need to repeat the characters here. The main differences are listed in the key. In addition to these, the anterior clasper of *S. latisetosa* appears slightly dished inwardly at the tip, sometimes giving the impression of a double tip. This is not the case in *S. laakei.*

Holotype: No. 43264, U. S. National Museum, collected during the period August 26 to September 6, 1929, at Menard, Texas, selected from a series of five male specimens chosen as the type and paratype series. These were trapped by Mr. E. W. Laake and Mr. E. C. Cushing in standard traps baited with decaying beef.

This species appears to be one of the most common species of Sarcophaga in Texas, and probably takes the place of *S. latisetosa* Parker in the south, much as *S. sueta* v. d. W. takes

*Hall, 1928, Ann. Ent. Soc. Amer., Vol. XXI, p. 331–352.

the place of *S. lhermenieri* R. D. Both *S. latisetosa* and *S. lhermenieri* R. D. are very common in the northern part of North America.

Sarcophaga coachellensis n. sp.

Male: Chaetotaxy essentially as in *S. quadrisetosa* Coq. but differing from this species, as well as others closely related, in the form of the anterior clasper, as listed in the key.

FIGURE 1. A, Claspers of *S. stimulans* Walk. B, Claspers of *S. laakei* n. sp. C, Claspers of *S. coachellensis* n. sp.

Holotype: No. 43265, U. S. National Museum, selected from a series of ten specimens which have been taken as the type and paratype series, these being from a good number trapped at Coachella, California, during the summer of 1929 in traps which were baited with decaying liver, urea, and water.

PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL MEETING.

Cleveland, Ohio, December 30 and 31, 1930.

The twenty-fifth annual meeting of the Entomological Society of America was held at Cleveland, Ohio, December 30 and 31, 1930. The program of forty-four papers was unusually interesting and touched almost every field in entomology. Approximately 200 members attended one or more sessions.

The Annual Public Address was given by Prof. H. J. Quayle, in the Auditorium of the Cleveland Museum of Natural History, and was attended by 1000 persons. The subject of Professor Quayle's illustrated talk was "Entomologists of Subtropical Countries," and was thoroughly appreciated by all.

Owing to difficulties arising at a late date which could not be overcome, the symposium, which had been an annual feature of our meetings, was omitted.

Opening Session, Tuesday Morning, December 30th.

The Society was called to order at 10:00 A. M., by President Edith M. Patch, in Room 105, Chemistry Laboratory, Case School of Applied Science, Cleveland, Ohio. The following papers were presented, either by the author or by title:

1. The Composition and Origin of the Insect Fauna of Hot Springs in the Western United States. (Slides and Moving Pictures.) C. T. Brues, Harvard University.
2. Insect Life of Oklahoma Salt Plains. (Lantern.) R. D. Bird, University of Oklahoma.
3. Preliminary Survey of the Aquatic Coleoptera of Presque Isle, Erie, Pa. (By Title.) John T. Gamble, Greenville, Pa.
4. A Flying Trip for Dragonflies to the West Indies. (Lantern.) J. G. Needham, Cornell University.
5. Notes on the Geographical Distribution of Florida Odonata. C. Francis Byers, University of Florida.
6. A Gynandromorph of *Chironomus decorus*. O. A. Johannsen, Cornell University.
7. Concerning Some Recent Trends and Suggestions in Taxonomy. C. H. Curran, American Museum of Natural History.
8. Classifying Symbols or a Placing System for Insects. E. P. Felt, Bartlett Research Laboratory.
9. The Genus Xerophoea (Homoptera, Cicadellidæ). (Lantern.) Paul B. Lawson, University of Kansas.
10. On the Length of the Adult Life in the Webbing Clothes Moth (*Tineola biselliella* Hum.) (Chart.) Grace H. Griswold, Cornell University.

The following committees were appointed by President Patch:

Nominating Committee—C. T. Brues, Chairman; Arthur Gibson, F. E. Lutz.
Auditing Committee—C. L. Metcalf, Chairman; T. H. Frison, C. R. Crosby.
Resolutions Committee—O. A. Johannsen, Chairman; W. V. Balduf, A. F. Satterthwait.

Second Session, Tuesday Afternoon, December 30th.

The Society was called to order by President Patch at 1:35 P. M. The following papers were presented:

11. European Entomologists and European Museums. (Lantern.) H. B. HUNGERFORD, University of Kansas.
12. Some Notes on Early Work in Entomology in Ohio. (Lantern.) HERBERT OSBORN, Ohio State University.
13. Mounting Coleoptera. (See Exhibits.) HENRY DIETRICH, Mississippi State Plant Board.
14. A Revision of Recent and Fossil Termopsinæ (Isoptera). (By Title.) ALFRED E. EMERSON, Chicago University.
15. A Study of the Genus Nemobius (Orthoptera, Gryllidæ). (Lantern.) B. B. FULTON, North Carolina Agricultural College.
16. The Larvæ of the Army Ants. (Lantern.) GEORGE C. WHEELER, University of North Dakota.
17. Evidence that *Macrocentrus ancylivora* Roh. and *M. delicatus* Cress., Parasitic on the Oriental Fruit Moth, are Morphologically and Physiologically Distinct Species. BYRLEY F. DRIGGERS and B. B. PEPPER, New Jersey Agricultural Experiment Station.
18. *Tibicen davisi:* A New Insect in the Field of Economic Entomology. (Lantern.) J. W. WILSON, Pierson, Florida.
19. Penetration of Petroleum Oils into Leaves and Twigs. (Lantern.) JOSEPH M. GINSBURG, New Jersey Agricultural Experiment Station.
20. Mosquito Control Work in Massachusetts. GEORGE S. TULLOCH, Museum of Comparative Zoology.
21. Insects in Relation to Plant Diseases. A. A. GRANOVSKY, University of Minnesota.

Third Session, Tuesday Evening, December 30th.

The Society was called to order by President Patch at 7:30 P. M., this evening session being held in the Auditorium of the Cleveland Museum of Natural History. The President introduced Prof. H. J. Quayle, who gave the annual address. Doctor Quayle's address, which was illustrated, was on "Entomologists in Subtropical Countries."

Fourth Session, Wednesday Morning, December 31st.

The Society was called to order by President Patch at 9:30 A. M. The following papers were presented:

22. The Habits of Leaf-mining Coleoptera from Panama. (By Title.) S. W. FROST, Pennsylvania Agricultural Experiment Station.
23. Notes on the Biology of the Stable Fly, *Stomoxys calcitrans* Linn. (By Title.) ROY MELVIN, Iowa State College.
24. The Bionomics of *Lipeurus heterographus* Nitzsch (Mallophaga), the Common Head Louse of Fowls: With Notes on Other Fowl Infesting Species. (Lantern.) F. H. WILSON, University of Richmond.
25. The Biology of *Tabanus lineola* Fabr. H. H. SCHWARDT, University of Arkansas.
26. Notes on Life History and Description of *Systelloderes biceps* Say, (Hemiptera, Enicocephalidæ). (Lantern.) A. F. SATTERTHWAIT, U. S. Bureau of Entomology.
27. Field Notes on Some Colorado Mosquitoes. (Lantern.) SHERMAN C. BISHOP, University of Rochester.
28. Studies on the Biology of *Paratrioza cockerelli* Sulc. GEORGE F. KNOWLTON and M. J. JONES, Utah University Agricultural Experiment Station.

29. Notes on Seventeen Year Cicadas in Kansas. R. H. BEAMER, University of Kansas.
30. The Magnolia Scale (*Neolecanium cornuparvum*). (Lantern.) GLENN W. HERRICK, Cornell University.
31. A Trip to Grasshopper Glacier. (Lantern.) GEORGE E. MARVIN, University of Wisconsin.
32. The Blueberry Maggot from an Ecological Viewpoint. F. H. LATHROP and C. B. NICKELS, U. S. Bureau of Entomology.
33. The Life History of *Hippelates pusio* Lw. in Coachella Valley, California. (Lantern.) DAVID G. HALL, U. S. Bureau of Entomology.
34. A Fourth Aquatic Hemipteron Having Only Four Nymphal Stages. WILLIAM E. HOFFMAN, Lingman University.
35. Notes on the Biology of Burrowing Mayflies. (Lantern.) ANN H. MORGAN, Mount Holyoke College.
36. Insects That Bite Man. (Lantern.) C. L. METCALF, University of Illinois.

Fifth Session, Wednesday Afternoon, December 31st.

The Society was called to order by President Patch at 1:30 P. M. The following papers were presented:

37. Factors Determining the Production of Winged and Sexual Forms of *Aphis spiraecola* on Citrus. J. R. WATSON, Florida Agricultural Experiment Station.
38. Tropisms and Sense Organs of Coleoptera. (Lantern.) N. E. MCINDOO, U. S. Bureau of Entomology.
39. The Proboscis Reflex of Insects. (Blackboard.) CYRIL E. ABBOTT, Ohio State University.
40. Anaphylactic Shock Following the Sting of Vespa. C. T. BRUES, Harvard University.
41. A Preliminary Report on Chironomid Larvæ Associated with Watersnails. (Lantern.) CLARENCE H. HOFFMAN, University of Kansas.
42. Importance of the Sex Ratio in Breeding Parasites. PHILIP GARMAN and JOHN C. SCHREAD, Connecticut Agricultural Experiment Station.
43. A Flying Trip among the Entomologists of the West Indies. JAMES G. NEEDHAM, Cornell University.
44. Measure of Adhesiveness Strengths of Calcium Arsenate. J. A. PARFENTJEV, St. Louis, Mo.

First Vice-President Snodgrass was called to the chair. The Annual Business Meeting followed.

REPORT OF THE SECRETARY.

Previous to July 1, 1930, the following, having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

EDWIN J. ANDERSON, Agricultural Experiment Station, State College, Pa.
JOHN WENDELL BAILEY, University of Richmond, Richmond, Va.
HORACE E. BELL, 56 Park St., Orono, Maine.
STEPHAN COLE BRUNER, Estacion Experimental Agronomica, Santiago de las Vegas, Havana, Cuba.
OWEN BRYANT, Banff, Alberta, Canada.
HORACE LESTER CALER, Box 12, Addison, Maine.
L. DEAN CHRISTENSON, Central Baragua, Camaguey, Cuba.
LAWRENCE H. DUNN, Gorgas Memorial Laboratory, Ancon, Canal Zone.
LONNIE CLIFTON ELMORE, Fork Union Military Academy, Fork Union, Va.
DONALD W. FARQUHAR, 296 Ames St., Lawrence, Mass.
ARTHUR MERTON GILLESPIE, Phi Eta Kappa, University of Maine, Orono, Maine.
MISS CHRISTINE HARDY, Dept. Entomology, Cornell University, Ithaca, N. Y.

GORDON W. HAUG, Dept. Entomology, A. & M. College, Mississippi.
H. A. JAYNES, Casilla Correo 74, Tucuman, Argentina.
BIRLEY J. LANDIS, 153 Calzada Tacuba, San Jacinto, District Federal, Mexico City, Mexico.
ULPHIAN CARR LOFTIN, Cuba Sugar Club Expt. Station, Central Baragua, Camaguey, Cuba.
ALONZO WILLIAM LOPEZ, P. O. Box 1493, Manila, Philippine Islands.
YUSHIRO MIWA, Dept. Agriculture, Government Research Institute, Taihoku, Formosa.
L. E. MYERS, Miss. St. Pl. Bd., A. & M. College, Mississippi.
ROBLEY WILSON NASH, Forest Service, State House, Augusta, Maine.
A. GLEN RICHARDS, JR., Dept. Entomology, Cornell University, Ithaca, N. Y.
LUIS C. SCARAMUZZA, Central Jaronu, Camaguey, Cuba.
GEDDIS W. SIMPSON, Dept. Entomology, Cornell University, Ithaca, N. Y.
JOHN W. WILSON, Pierson, Florida.
LOUIS W. ZIEGLER, Agricultural Experiment Station, Gainesville, Florida.

With the approval of the Executive Committee, Prof. H. J. Quayle was invited to give the annual public address of the Society at the Cleveland meeting.

J. S. Houser kindly consented to act as chairman of the Arrangements Committee. He was ably assisted by J. C. Pallister.

During the year the following appointments were made by President Patch:

Dr. J. N. Chapman was appointed the Society representative for the Division of Biology and Agriculture of the National Research Council. Owing to his transfer of residence to Hawaii, Doctor Chapman resigned the appointment and Dr. F. E. Lutz was appointed to fill the vacancy.

Dr. E. D. Ball was appointed to represent the Society at the inauguration of Doctor Shantz as President of the University of Arizona.

The Executive committee met at 4:30 P. M., December 30, in the Library Room of the Chemical Laboratory, Case School of Applied Science, the following members being present: Edith M. Patch, Herbert Osborn, C. L. Metcalf, P. J. Parrott, and J. J. Davis. F. E. Lutz was also present as an alternate designated by the President.

The following were elected to membership in the Society:

ERNEST ADNA BACK, Bur. Entomology, U. S. Dept. Agric., Washington, D. C.
SAMUEL C. BILLINGS, Insecticide Testing Labry., R. No. 1, Silver Spring, Md.
EBER CECIL BARR, 1471 Michigan Ave., Columbus, Ohio.
JAMES MARKS BRENNAN, Dept. Entomology, Kansas University, Lawrence, Kansas.
FERDINAND H. BUTT, 708 Stewart Ave., Ithaca, N. Y.
M. T. CHEO, Dept. Entomology, Cornell Univ., Ithaca, N. Y.
WILLIAM HODGES CLARKE, Peach Experiment Station, Thomaston, Ga.
RALPH H. DAVIDSON, Dept. Entomology, Ohio State Univ., Columbus, Ohio.
ERNEST J. DORNFELD, 212 E. North Ave., Milwaukee, Wis.
MISS DOROTHY DOTTERER, Dept. Zoology, Univ. Pittsburgh, Pittsburgh, Pa.
RAY THOMAS EVERLY, 425 Fourth St., Toledo, Ohio.
LOWELL J. FARMER, Moscow, Idaho.
STANLEY E. FLANDERS, Citrus Expt. Station, Riverside, Calif.
CHARLES E. FOSTER, Colgate University, Hamilton, N. Y.
H. T. FENG, Dept. Entomology, Cornell Univ., Ithaca, N. Y.
GEORGE H. GEISSLER, Box 167, Vincennes, Ind.
NEWELL E. GOOD, 2000 H. St., N. W., Washington, D. C.
LOUISE ELIZABETH HAAS, Dept. Zoology, Iowa State College, Ames, Iowa.
ROWLAND WELLS HAEGELE, Dept. Entomology, Idaho Agr. Expt. Station, Parma, Idaho.
HELEN FOWLER HAYDEN, 207 Fall Creek Drive, Ithaca, N. Y.
CHARLES H. HICKS, 823 Harvard Rd., Burbank, Calif.
SAM ODOM HILL, 10 Court St., Arlington, Mass.
WILLIAM BURNELL HOLLINGSWORTH, Box 415, Picayune, Miss.

Y. C. Hsu, Dept. Entomology, Cornell Univ., Ithaca, N. Y.
Miss Gwladys Hughes, Dept. Entomology, Cornell Univ., Ithaca, N. Y.
Ross Elliott Hutchins, State Pl. Bd., A. & M. College, Mississippi.
Melvin J. Janes, Utah Agr. Expt. Sta., Logan, Utah.
S. E. Jones, Texas Agr. Expt. Sta., College Station, Texas.
Shizuo Kato, Entomological Institute, Hokkaido Imperial University, Sapporo, Japan.
Edward F. Knipling, 2121 Lincoln Way, Ames, Iowa.
Erskine M. Livingstone, 515 Jefferson St., Danville, Va.
James Marion McGough, Estacion E. Agronomica, Santiago de las Vegas, Havana, Cuba.
A. Gordon McNally, 390 Colborne St., London, Ontario, Canada.
L. Chester Morston, Jr., Dept. Biology, Univ. Toronto, Toronto, Canada.
H. C. Mason, 151 W. Eleventh Ave., Columbus, Ohio.
Forrest W. Miller, Dept. Zoology, University of Pittsburgh, Pittsburgh, Pa.
Ronald C. Mundell, Box 509, Uvalde, Texas.
A. Musgrave, Australian Museum, Sydney, N. S. W., Australia.
Bailey B. Pepper, Dept. Entomology, Ohio State University, Columbus, Ohio.
Don M. Rees, University of Utah, Salt Lake City, Utah.
Paul E. Schaefer, Dept. Entomology, Ohio State University, Columbus, Ohio.
Morris Schlosberg, 615 Front St., Toledo, Ohio.
S. W. Simmons, A. & M. College, Mississippi.
E. Graywood Smyth, Hacienda Cartavio, Salaverry, Peru.
Benjamin R. Speicker, Dept. Zoology, Univ. Pittsburgh, Pittsburgh, Pa.
J. Sedley Stanford, Utah State Agr. College, College Hill, Logan, Utah.
William Walter Stanley, Tennessee Agr. Exp. Sta., Knoxville, Tenn.
A. L. Strand, Montana State College, Bozeman, Montana.
Miss Jay R. Traver, Dept. Entomology, Cornell University, Ithaca, N. Y.
Benard V. Travis, Dept. Zoology, Iowa State College, Ames, Iowa.
Harry Granville Walker, Virginia Truck Exp. Sta., Norfolk, Va.
Russell R. Whitten, 104 Ashland St., Melrose, Mass.
Miss Inez Williams, Fernald Hall, Amherst, Mass.
George Charles Woodruff, Box 615, University Station, Baton Rouge, La.
Archibold McFarland Woodside, Dept. Entomology, Virginia Agr. Exp. Sta., Blacksburg, Va.

Total new members during 1930—80.

The following three members paid $50.00, thereby becoming Life Members:

Mrs. Gaston Fournier.
Miss Edith W. Mank.
Dr. C. W. Johnson.

The following were elected Fellows of the Society:

H. G. Barber,
Henry Bird,
D. M. DeLong,
W. T. M. Forbes,
R. Jeannel,
W. D. Pierce,
A. F. Satterthwait,
O. H. Swezey,
M. C. VanDuzee.

The following members have resigned during the year: H. C. Atwell, Martin Bowe, E. H. Wheeler, M. C. Marshall, M. B. Dunn, Joseph Krafka, Jr., Fred E. Pomeroy, Karl W. Johnson, A. A. Mathewson, T. E. Snyder.

The following members have been automatically dropped from the membership list: Alice P. MacDougal, Laurel Setty, Fred M. Brown, Ernest A. Neilson.

The Society has suffered the loss of the following members:

Frank A. Leach died last year, June 19, 1929, but was not recorded in the minutes of the last meeting.

STEPHEN ALFRED FORBES died March 13, 1930, at the age of 85 years and 9 months. He was the President of this Society in 1912, and one of the outstanding entomologists of the world. His remarkable record, not only as an entomologist, but as an ornithologist, an ichthyologist, and as an ecologist are vouched for by his writings and the fact that he was variously known as "Dean of American Economic Entomologists," as "The First Economic Ornithologist in America," and as "The Founder of the Science of Ecology." Quoting the last paragraph in an obituary written by Dr. Metcalf and published in the May, 1930, *Entomological News:* "Fearless, eternally youthful, unostentatiously confident and inspiring, never seeking favor or preferment, but continually in demand by recognition of his worth, this man was revered by his peers and colleagues for his breadth and clarity of vision, his kindly, helpful criticism and sympathy, his infectious enthusiasm, his brilliant intellect and impregnable strength of character, and his loyal and genial friendship."

DR. WILLIAM BARNES died May 1, 1930. A surgeon of national reputation, he became even more famed by his vocation as a Lepidopterist. The remarkable collection of Lepidoptera which he built up and the valuable monographs which he published will ever stand as a monument to his greatness as a taxonomist.

DR. H. J. PACK died June 5, 1930.

DR. M. M. WELLS died August, 1930. He was president of the General Biological Supply House of Chicago and was always interested in promoting entomology and allied subjects. He was scientifically trained and was a genuine scientist. At the time of his death, he was preparing a Field Book in Biology and his training and interest assured a valuable and useful work.

REV. V. A. HUARD died October 15, 1930.

DR. J. H. EMERTON died December 5, 1930, in his eighty-fourth year. He was for many years interested in entomology and is known to us as one of the best known authorities on spiders.

GEORGE G. AINSLIE died December 20, 1930. He was for many years connected with the Cereal and Forage Insect Division of the Federal Bureau of Entomology and is especially known for his economic and taxonomic work on the Crambidæ.

PROF. J. S. HINE died December 22, 1930. He was a teacher of ability and well known to the entomological fraternity as a taxonomist in the Order Diptera. But to those who knew him intimately, he was appreciated because of his helpful and kindly ways.

Prof. Herbert Osborn was appointed as elector to select the Society Representative for the Division of Biology and Agriculture of the National Research Council.

The matter of a National Biological Society was laid on the table without action.

It was recommended to the Society that it again contribute $25.00 to the Zoological Record.

A report was received from Arthur Gibson, who represented the Society at the Third Imperial Entomological Conference, held in London. Mr. Gibson presented greetings from our Society and in return was thanked for the greetings extended and was requested to present to our Society the good wishes of the Conference for the future success of the Entomological Society of America.

It was recommended that hereafter there should be a committee of one to present Memorials at each annual meeting.

The committee recommended the appointment of the following members on the Editorial Board: J. MCDUNNOUGH, HENRY BIRD, and E. B. WILLIAMSON.

Respectfully submitted,

J. J. DAVIS, *Secretary.*

On motion the Secretary's Report was accepted and the recommendations adopted.

REPORT OF THE TREASURER.

CURRENT FUNDS.

RECEIPTS.

Balance, December 31, 1929, (See Annals, XXIII, p. 202)	$2,510.02
From Annual Dues of Members to December 20, 1930	2,770.30
Received from T. D. A. Cockerell for Zoological Record Fund	5.00
Received from Annals	1,337.79
Received from Three Life Memberships	150.00
Interest on Liberty Bonds	15.52
Interest on Savings Account to December 31, 1930	213.28
Total	$7,001.91

EXPENDITURES.

Telegrams, etc	$ 2.69
Refunds for Excess Payments	2.00
Zoological Record	30.25
Lafayette Printing Co., Letterheads	8.00
Haywood Publishing Co., Filing Equipment	6.75
Spahr and Glenn Co., Printing of Annals for December, 1929, March, June and September, 1930	3,793.64
Clerical Service	53.67
Stamps and Stamped Envelopes	49.50
J. C. Moore Co., for Account Book Forms	3.22
Spahr and Glenn Co., Envelopes	6.25
Lafayette Printing Co., Nomination Blanks and Announcements	34.00
Lafayette Printing Co., Envelopes and Dues Cards	11.25
Lafayette Printing Co., Programs and enclosures	24.50
Reimbursement on Returned Checks	6.00
Exchange on Checks	4.80
	$4,036.52
Transferred to Permanent Fund—3 Life Memberships	150.00
Transferred to Permanent Fund—Interest	228.80
Total	$4,415.32
Balance in Bank	2,586.69
Total	$7,002.01

LIABILITIES.

The Society owes the publishers for the December, 1930, Annals and a few miscellaneous expenses, and $1,344.00 of the above cash receipts are 1931 dues.

PERMANENT FUND.

Liberty Bonds, (Annals XXIII, p. 202)	$ 350.00
In Purdue State Bank, (Annals XXII, p. 202)	2,039.89
Three Life Memberships	150.00
Interest on Savings and Liberty Bonds	228.80
Total	$2,768.69

RESOURCES.

Liberty Bonds	$ 350.00
Savings Account, Purdue State Bank	3,700.24
Balance in Checking Account, Purdue State Bank	1,305.14
Total	$5,355.38

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

On motion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE MANAGING EDITOR OF THE ANNALS.

I wish to report that the Annals has had the best year of its existence in the variety and quality of the articles submitted, in the quality of its illustrations and in the amount of material published. Much of the text was put into ten-point type in order to get more articles into the limited space. For the first time the annual volume has exceeded 800 pages. Probably the volume for 1931 will be as large. The help of a grant of $500.00 from the National Academy of Science should be noted. Enough material is on hand for the March, 1931, number, which is now in the hands of the printer and some material for the June number.

I wish to thank Professor Osborn for continued interest and advice and for aid during the summer when the Editor is out. I wish to speak my appreciation of the printers, The Spahr and Glenn Company, and of Mrs. Elizabeth A. Davis, who has kept books that balance.

The financial summary follows:

RECEIPTS.

Non-member Subscriptions	$ 575.77
From Sale of Back Volumes, Numbers and Reprints	716.47
From Engravings	537.15
From National Academy of Science	500.00
From Other Irregular Items	24.00
Total	$2,353.39

DISBURSEMENTS.

Mailing Charges, Postage and Wrappers	$ 114.36
Stenographic Service	268.66
Moving Annals stores to New Quarters	34.50
Engraving Bills	472.63
Incidentals	21.65
Check Returned	11.80
Reprints for Tropical Research Foundation	78.00
Membership Fees Passed on to J. J. Davis	14.00
Two Checks to J. J. Davis, Treasurer	1,337.79
Total	$2,353.39

Vouchers are submitted herewith.

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor.*

On motion this Report was accepted, subject to the approval of the Auditing Committee.

No report was received from the Editor of the Thomas Say Foundation but the Treasurer, J. J. Davis, explained that a manuscript, intended for Volume 3, had been submitted to printers for estimates and the Committee hoped to be in a position to go ahead with publication early in 1931.

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION.

FOR THE YEAR 1930.

RECEIPTS.

Balance on hand January 1, 1930, (See Annals XVIII, p. 206)		$ 33.64
Interest on Savings Account to January 30, 1930		1.90
Received from sale of Volumes I and II		66.45
Received as Donations to Publication Fund:		
C. F. Adams	$10.00	
Wm. T. Davis	10.00	
Henry Bird	17.00	
Franklin Sherman	5.00	
J. M. Aldrich	20.00	
H. E. Ewing	5.00	
Total		67.00
Received as Loan—J. C. Bradley		10.00
Received for Future Volumes:		
C. W. Johnson	$10.00	
E. P. Felt	5.00	
Franklin Sherman	5.00	
W. A. Riley	10.00	
		30.00
Received from Heckcher Fund of Cornell University for publication of Volume 3		700.00
Total Receipts		$908.99

EXPENDITURES.

Postage on Mailed Volumes	$ 2.35
Interest on Loan	19.50
	$ 21.85
Balance in Purdue Bank	887.14
	$908.99

There is a balance due on loan to pay for printing Volume 2, of $325.00.

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

On motion the Report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE AUDITING COMMITTEE.

1. That we have examined the accounts of the Treasurer of the Society, the Managing Editor of the Annals and the Treasurer of the Thomas Say Foundation and find the items given to be correct and properly balanced.

2. To save the time of the Secretary-Treasurer and other members during the busy Convocation Week, we suggest that the Auditing Committee be appointed well in advance of the meeting and the work of auditing completed before the meetings begin.

3. That the Auditing Committee be authorized to employ the services of a certified public accountant if they so desire.

Respectfully submitted,

C. L. METCALF, *Chairman,*
T. H. FRISON.

(The third member of the committee, C. R. Crosby, was not present at the meetings.)

On motion the Report of the Auditing Committee was accepted and the recommendations adopted.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

Resolved, That the Secretary be instructed to convey to the authorities of the Case School of Applied Science and Western Reserve University, the gratitude of the Entomological Society of America for the accommodations they have furnished for the sessions just ending.

Resolved, That we express our great appreciation to the Director and Trustees of the Cleveland Museum of Natural History for the excellent facilities provided for the Annual Public Address.

Be it further Resolved, That thanks be extended to Prof. J. S. Houser, as Chairman of the Arrangements Committee, and to Mr. J. C. Pallister, of the Cleveland Museum of Natural History, for their efficient work in providing facilities for the meetings.

Respectfully submitted,

O. A. JOHANNSEN, *Chairman*,
A. F. SATTERTHWAIT,
W. V. BALDUF.

By vote of the Society, the Report of the Resolutions Committee was accepted.

Dr. F. E. Lutz reported briefly on the Division of Biology and Agriculture of the National Research Council.

REPORT OF THE NOMINATIONS COMMITTEE.

The Nominating Committee beg to report the following names as nominees for the respective offices for the year 1931:

President—J. W. FOLSOM.

First Vice-President—J. M. SWAINE.

Second Vice-President—HAROLD MORRISON.

Secretary-Treasurer—J. J. DAVIS.

Additional Members of the Executive Committee—For the term expiring 1933—R. C. OSBURN and W. T. M. FORBES.

Councillors to the American Association for the Advancement of Science—P. P. CALVERT and W. E. BRITTON.

National Museum Committee—C. W. JOHNSON and E. C. VANDYKE.

Respectfully submitted,

C. T. BRUES, *Chairman*,
FRANK E. LUTZ,
ARTHUR GIBSON.

On motion the report was accepted and Vice-President Snodgrass was instructed to cast a ballot for the election of the persons nominated. This being done, they were declared elected.

The Committee on Insect Collections reported as follows:

REPORT OF THE COMMITTEE ON INSECT COLLECTIONS.

In presenting the following statements concerning the progress of the insect collections it may be stated that we have included reference to some private collections which may have a special value to entomological workers and we would call attention to the desirability of having information from the different entomological centers as to their willingness and facilities for giving identification in the different groups of insects.

Some of our members feel that there should be a greater recognition of the value of this kind of service and that some kind of compensation should be expected, especially when there is no equivalent return for the service requested. We are confronted with the fact that frequent demands are made upon specialists for service requiring much time as well as technical knowledge and with little or no return for the service.

Perhaps the most notable occurrence for the year has been the acquiring of the Barnes Collection of Lepidoptera for the U. S. National Museum. The contents of this collection is referred to in the report from the Museum but it deserves special mention since it is undoubtedly one of the very valuable collections to be found in this group and, moreover, is of distinct interest to our society because the acquisition by the Museum was no doubt facilitated by active support from a number of the society members. We may also feel gratified that special curator service for the collections in Hemiptera has been provided.

On the whole it appears that our insect collections are making substantial progress and becoming more and more prepared to serve entomological workers throughout the country.

It may be added that requests for information were sent to a number of public and semi-private or private collections which have not as yet been reported and it seems desirable to continue the requests for such information and the Committee will welcome statements from any organization which may have been overlooked.

U. S. National Museum, Washington, D. C. I am able to report that the Barnes Collection of Lepidoptera has come to the National Museum, through an appropriation made by Congress. This collection contains in the named series 1136 drawers with about 150,000 specimens; about 1000 species are represented by types and 800 more by cotypes and paratypes. There were about 4000 species represented by specimens that have been compared with types in American and foreign museums, and are so labeled. There are many microscopic slides of genitalia, etc. In addition to the determined part of the collection, there are about 300,000 other specimens more or less classified. The Brooklyn Museum through a change of policy has decided to devote itself to popular exhibits, and its general collection of insects was deposited in this Museum, including about 37,000 specimens and 477 types of species. We have also received through the year about 50,000 specimens of Chinese insects from David C. Graham of Suifu, Szechwan, China; these were all undetermined.

—J. M. ALDRICH, Associate Curator, Division of Insects.

American Museum of Natural History, New York City. I have checked up our accessions for the past year and find that the American Museum collection of insects, through donations and collections made by our staff, has been enriched by about 16,000 specimens. The larger donations include 1200 North American beetles from Mr. H. G. Barber and about 1000 miscellaneous North American insects from Mr. E. L. Bell. A number of smaller donations have been received from different parts of the globe. In these, the West Indies are represented by more than 1200 miscellaneous insects and Tropical Africa by about 1000 specimens, most of which are Lepidoptera. The principal collections made by the Museum staff are about 6000 specimens, mostly Diptera, collected by Mr. C. H. Curran in the vicinity of Cold Spring Harbor, Long Island and Ontario, Canada. Several hundred miscellaneous insects, including a number from the thermal springs, were collected at Yellowstone, Wyoming by Dr. F. E. Lutz.

—A. J. MUTCHLER, Associate Curator.

Museum of Comparative Zoology. During the past year the following collections were received: The Chilean Hymenoptera of the late Paul Herbst, about 8000 specimens, partly named; about 1000 specimens from Hawaii collected by Dr. Wheeler; about 2000 obtained by Prof. C. W. Dodge in Costa Rica; over 2000 taken by Arthur Loveridge in Tanganyika Terri and Rhodesia; about 6000 insects from Southern Mindanao, Philippine Islands, collected by C. S. Clagg; the Lepidoptera of the late C. J. Paine, largely New England, but many western and exotica, largely named, about 10 to 12,000 specimens; the Geometridæ of the late Louis Swett, over 1000 specimens, mostly named and about 40 types; about 5000 specimens collected in the mountains of North Carolina and Tennessee by a Museum Expedition consisting of the Curator, Mr. Carpenter, and Mr. Darlington; the general collection of the Bussey Institution, mostly Lepidoptera, and with the types of a few aberrations by Reiff; about 1000 insects taken in Wyoming and South Dakota by Mr. G. Fairchild; over 1000 (mostly Hymenoptera) taken in Arizona in 1917 by Dr. Bequaert; others taken by Dr. Bequaert in Yucatan, and by Mr. Stadelmann in Honduras. Over 1000 spiders given by Mr. Emerton, and about as many from Mr. Creighton in the Southern States. These with various smaller lots bring the additions to fully 45,000 specimens.—NATHAN BANKS.

Boston Society of Natural History. Dr. R. Heber Howe has recently presented to the Society his entire collection of New England Odonata comprising 152 species, represented by over 1000 specimens, together with over 500 specimens of their nymphs, both dry and in alcohol. It is by far one of the finest local collections of this order ever brought together. The value of the collection is greatly enchanced by its being the basis of Dr. Howe's valuable *Manual of the Odonata of New England*, published in six parts (March, 1917, to March, 1920) and comprising 102 pages with illustrations of all the species. A supplement was published in March, 1921, adding eight species, making the total number of species for New England, 164. In May, 1921, Dr. Howe published an interesting paper in the *Proceedings* on "The Distribution of New England Odonata." Later he extended his Manual to cover the nymphs publishing 3 parts (December, 1921, to November, 1927) comprising 47 pages with illustrations, keys and figures. His work has added much to our knowledge of the dragon flies of this region and the collection is a most valuable addition to the Society's collection.—C. W. JOHNSON.

Utah Experiment Station. The insect collection here consists principally of insects collected within the boundaries of the state. Most of the collecting has been done in connection with work on various projects. During the past two years, 2000 insects have been added to the collection, in connection with the alfalfa insect studies. Several thousand insects have been pinned, from the large amount of material collected in connection with beet leafhopper and miscellaneous insect investigations.—G. F. KNOWLTON.

The University of Nebraska. As in 1929, the insect collection here received considerable attention in the matter of rearrangement of the collection. Certain groups have been entirely gone over and much new material incorporated. Mr. E. F. Powell has completely named and rearranged the *Chrysomelini* and Professor D. B. Whelan is doing the same for the *Halticinæ* in the beetle family Chrysomelidæ. Mr. R. H. Nelson named and arranged the Culicidæ in the collection. Mr. O. S. Bare added extensively to the Formicoidea in the collection during 1930. Mr. Raymond Roberts, having named and rearranged the collection of Vespoidea in 1929 and previously, in 1930 worked intensively on the Scoliidæ, naming and incorporating material from Colorado, Oregon, California and other western states.—MYRON H. SWENK, Chairman, Department of Entomology.

Purdue University. I am not sure that I have ever given you a statement of specimens in the Purdue University Entomological Collection. My estimate is as follows: Hymenoptera, 2000, Diptera, 1000, Lepidoptera, 6000, Coleoptera, 35,000, Hemiptera, 2500, Homoptera, 3500, Odonata, 1500, Orthoptera, 2000, Other Orders, 1000, Total, 54,500. In addition, Dr. C. F. Adams has recently donated his collection of Diptera of about 12,000 specimens.—J. J. DAVIS.

Massachusetts Argicultural College. I may say, as regards the growth of the collection at this college, that only normal progress has been made. This has been developed chiefly in the order Coleoptera through the continued kindly

interest of Mr. C. A. Frost. The curator of the collections has continued the rearrangement of the Coleoptera, and about one-half of the families of this order are now in their permanent cases.—CHARLES P. ALEXANDER.

Also, Doctor Alexander says concerning his personal collection, "To the date of November 1st, my collection of crane-flies includes 4,770 species, of which 3,585 species are represented by type material either holotype, allotype, or paratype. This collection includes the families Tanyderidæ, Ptychopteridæ, Trichoceridæ, and Tipulidæ."

Clemson Agricultural College, Clemson, S. C. Developing a general and economic collection, chiefly of state fauna; in Schmitt boxes and glass-topped cases. About 350 boxes and cages now in use. Following groups best represented· Acrididæ, larger Heteroptera, Cicindelidæ, Carabidæ and Cerambycidæ. A card-catalogue record of state fauna is maintained.—FRANKLIN SHERMAN, JR.

The entomological collection of the *Brigham Young University* consists of over 75,000 pinned specimens, and 500 specimens mounted upon slides. The pinned insects are placed in three hundred trays, 18 x 19 inches in size, two inches deep and 150 Schmitt boxes. The specimens are pinned in unit boxes. The Lepidoptera collection is a very complete one of Utah and the Great Basin region. It contains over 600 named species and 10,000 specimens. It is made up of the famous Tom Spalding collection and the Chester Van Buren collection of South American butterflies. The Coleoptera collection contains over 5000 determined species and 30,000 specimens. It contains a very complete collection of weevils, 300 species from the Blatchley collection. It is the aim of the University to make this collection a very complete one of the species of the Great Basin region.
—VASCO M. TANNER.

Illinois State Natural History Survey, Urbana, Illinois: During the past year the Survey collection of insects has continued to grow due to collecting in various localities throughout the state by members of the staff. Special attention was devoted last summer to completing a survey of the plant lice of Illinois with the result that 1,500 slides were added, bringing the total number of slides of plant lice to approximately 12,000. A survey of the plant bugs of the state was started with the result that some 2,000 specimens were added to the already extensive series of these insects in our collection. This plant bug survey will be continued for several summers. Another group of insects receiving special attention was the stoneflies, or Plecoptera, and our collection was increased by about 500 specimens preserved in fluid. About 2,000 specimens of insects, belonging to various groups, were added to the collection incidental to work on special projects. The Survey received by donation another series of Cynipidæ, including galls and some types, from Dr. A. C. Kinsey, besides a few other specimens and types in diverse groups of insects.—THEODORE H. FRISON.

Experiment Station, Hawaiian Sugar Planters Association. We have no new or important features to report on since the report that was published on page 205 of Ann. Ent. Soc. America, 23, No. 1, 1930. A line has been omitted, which leaves out reference to our large collection of Fulgoroidea which was worked up and arranged by Dr. Muir. In line 30, p. 205, following "worked up," it should have read, "much of the Fulgoroidea, however, have been worked up and are arranged in a large cabinet. There are several hundred types."—O. H. SWEZEY.

Kansas State Agricultural College, Manhattan, Kansas. "We would mention first the general collecting trip made by Dr. R. H. Painter and Mr. T. F. Winburn, in the southwestern part of the United States in which somewhere between 5,000 and 6,000 specimens in the various orders were collected. Of particular significance is the addition of Bombyliids which includes approximately 100 species distributed in 25 genera, several of which are very rare and heretofore known only by type. Mr. Hobart Smith, a senior student, also made a trip in the Southwest and collected approximately 1,000 specimens, consisting largely of Coleoptera. A collection of six Schmidt boxes of the more common insects of Haiti was brought to the department by the writer during the war. An addition of approximately 1,500 specimens of Homoptera was made to the collection by Prof. D. A. Wilber in the course of the season's collecting. The alcoholic collection was worked over during the year and there was installed the method of hanging the vials on

an upright woven wire frame. This method has much to commend it. Mention was not made in last year's report of the purchase of three steel cabinets holding 75 Schmidt boxes each for the Knaus collection of Coleoptera, and of three steel cabinets holding 50 insect drawers for the department's permanent collection. These cabinets will enable us to keep our collection in better condition than ever before. Members of the department are willing to make determinations in the family Bombyliidæ and North American Neuroptera.—ROGER C. SMITH.

Indiana University. In addition to the general collections for teaching purposes, we continue to build up our collection of *Cynipidæ*. In this single family, including both gall wasps and galls, we have something over a million specimens, perhaps 350,000 of these being insects. The yearly increment averages 25,000 bred insects and three times that many galls. During the past year we have bred over 100,000 insects, about 75,000 of which represent a single species whose evolutionary status we have under especial investigation. The collection is preserved in pest-proof equipment in a fire-proof building. We can offer complete facilities to students who may care to study our material.—ALFRED C. KINSEY.

HERBERT OSBORN, *Chairman*,
JAS. G. NEEDHAM,
CHAS. W. JOHNSON,
NATHAN BANKS,
EDW. C. VAN DYKE.

J. Chester Bradley moved that a committee of three be appointed by the President to aid in making arrangements for the International Congress of Entomology to be held in Paris in 1932. Motion seconded and carried.

No report received from the Historical Committee.

C. H. Curran moved that the Society be authorized to loan to the Thomas Say Foundation a sum up to $500.00, from the Permanent Fund in order to finance the publication of volume 3 of the Foundation, the final approval of the loan subject to the approval of the Executive Committee. Motion seconded and carried.

The Secretary read a letter from C. W. Stiles calling attention to an amendment to the Law of Priority in nomenclature, which becomes effective January 1, 1931. The amendment reads as follows:

ARTICLE 25.—

But no generic names nor specific name published (as new) after December 31, 1930, shall have any status of availability (hence also of validity) under the Rules, unless and until it is published either

1. with a summary of characters (seu diagnosis; seu definition; seu condensed description) which differentiate or distinguish the genus or the species from other genera or species;

2. or with a definite bibliographic reference to such summary of characters (seu diagnosis; seu definition; seu condensed description). And further

3. in case of a generic name, with the definite unambiguous designation of the type species (seu genotype; seu autogenotype; seu orthotype).

Meeting adjourned.

The Annual Entomologists' Dinner, attended by 225 entomologists, was held in Hayden Hall of Western Reserve University, Wednesday evening, December 31.

Respectfully submitted,

J. J. DAVIS, *Secretary*.

BOOK NOTICES.

RECENT ADVANCES IN ENTOMOLOGY. By A. D. IMMS. Pages I–VIII and 1–374, 84 figures. Published by P. Blakiston's Son and Company, Inc., Philadelphia, 1931.

This volume is remarkable in the care given to the selection of material, in the broad field covered and in the grasp of the essential problems in each field. "It attempts to review and discuss certain aspects of the subject along which recent advances have been fertile in new facts and ideas." In fifteen chapters it covers the problems and recent advances in Morphology, chapters I and II, Metamorphosis, III, Palaeontology, IV, Sense Organs and Reflex Behavior, V and VI, Colocation, VII, Ecology, VIII–XI, Parasitism, XII and XIII, and Biological Control, XIV and XV.

There is an index to authors and a very complete general index which makes it very usable. It is a book that every entomologist in the pure science will want and every man in applied entomology must have. Incidentally it shows the broad grasp of the author on all fields of entomology.—C. H. KENNEDY.

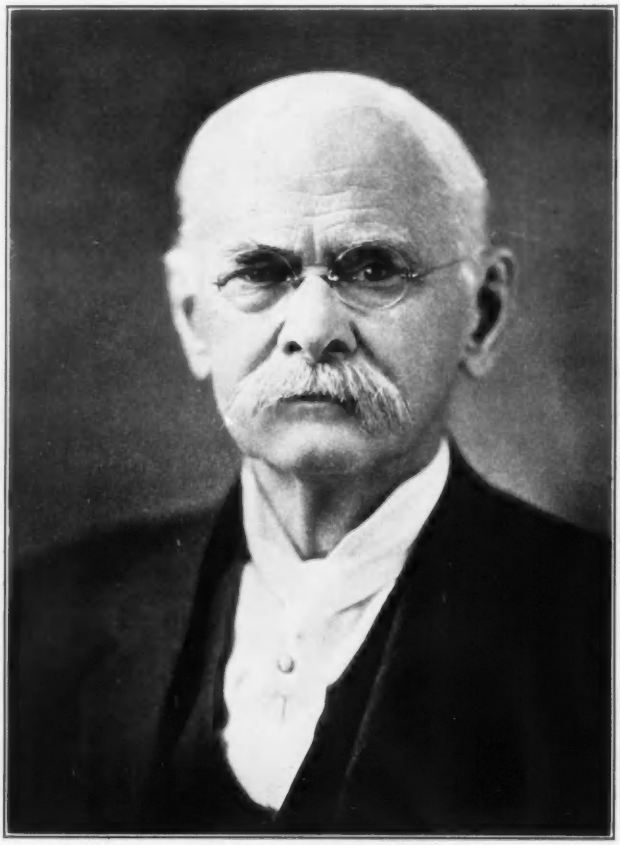
HISTOLOGICAL AND ILLUSTRATIVE METHODS FOR ENTOMOLOGISTS. By H. ELTRINGHAM, F. R. S., F. E. S., F. Z. S., with a Chapter on mounting whole insects by H. BRITTEN, F. E. S. Pages I–XII and 1–139, 21 figures. Published by Oxford University Press.

This book is of special interest because it outlines the methods used by Eltringham in his own exacting work on the histology of obscure organs in insects. The long series of his papers of a histological nature that have appeared in the Transactions of the Entomological Society of London have made all morphologists wish for a detailed account of his technique. This the volume gives. There are nine unnumbered chapters covering such subjects as Apparatus, Reagents, Materials; Wings, Scales; Genitalia; Fixing, Embedding, Section-cutting; Staining; Preparation of Whole Small Insects (by Britten); Drawings; Lantern Slides and Photographs; Models. The book is thoroughly indexed and is very usable because of the numerous black-face headings.

—C. H. KENNEDY.

A MANUAL OF THE GENERA OF BEETLES OF AMERICA, NORTH OF MEXICO. Keys for the determination of the families, subfamilies, tribes and genera of Coleoptera with a systematic list of the genera and higher groups. By J. CHESTER BRADLEY. Pages I–XII and 1–306. Lithoprinted (Mimeograph). Published by Daw, Illston & Co., Ithaca, New York.

This is a mimeograph publication of the keys to the genera of Coleoptera prepared by Bradley for his classes. It is a compilation from the latest and best keys and appears to be the first key covering America North of Mexico since LeConte and Horn in 1883. It is to be used with Leng's catalogue which is a key to the literature of species. In parts of the work alternate keys from two or more sources are given. It is dedicated to W. S. Blatchley and is thoroughly indexed to genera and all higher groups. The systematic arrangement follows Leng's catalogue. It is lithoprinted by Edwards Brothers of Ann Arbor, a new process using metal plates and producing very clear and clean text.—C. H. KENNEDY.



JOHN HENRY COMSTOCK